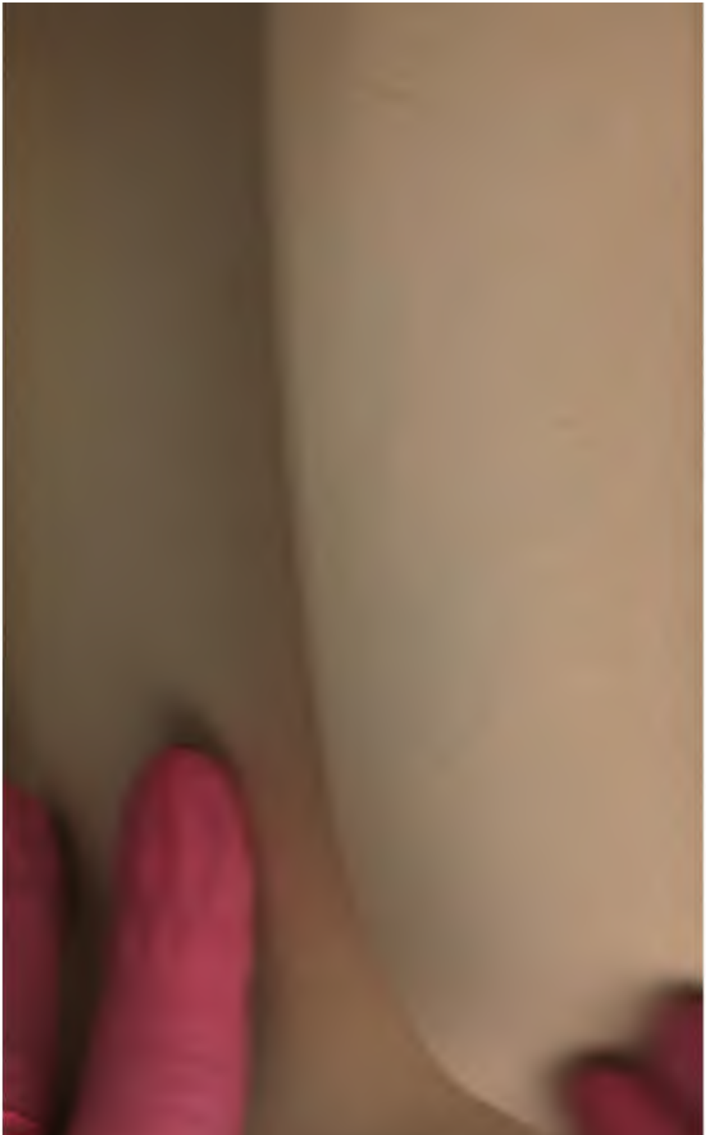
ALEXANDER'S
READY REFERENCE



Yours Truly
J. A. Alexander

Broke Down: What I Should Do.

READY REFERENCE AND KEY

—FOR—

Locomotive Engineers

—AND—

FIREMEN,

Round House Machinists, Conductors, Train Hands and Inspectors.

By S. A. ALEXANDER, York, Pa.

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1890.

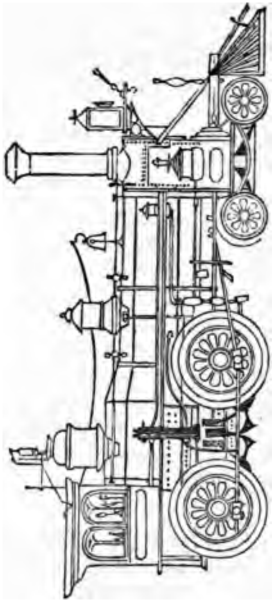
PREFACE.

This book is written for the special information of Engineers and Firemen who have to do work on their Engines while away from repair shops. It is only what its title implies—that is a ready Reference directing what should be done in emergencies. Most of the reasons why the instructions should be followed, will be found, at the latter part of this book, under the head, "The Reason Why." This section has its own index. If you are not sure you are right inquire of some one who knows. Some of my instructions are different from shop practice and are so of necessity, because you would not have the same facilities for doing the work while away from the shops. For example: In my methods for dividing valves with the steam chest lids off, it is taken for granted that the links lift both alike, that the saddle pin is in proper position, and that the radius or curve of the link is correct. Such work must be corrected in the shops but it is not probable that any of these would get out of order by ordinary use, and by using the methods given the valves will beat square in the place where they are mostly used, and in a large majority of cases will be correct in every notch, if they ever were right.

I cannot find time to reply to all of the numerous and flattering letters sent me by the readers of the Ready Reference. I value those letters very highly and I thank the writers with all my heart. It is pleasant to me to feel that I have been of some benefit to some person. I hear that the book has been a great aid in transferring a number of the Boys from the left to the right side.

Very truly yours,

S. A. ALEXANDER.



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PROTECT YOURSELF FROM APPROACHING TRAINS.

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BROKE DOWN.

DISCONNECTING.

When an engine is to be towed by another engine the main rods should be taken off; the valve rods should be disconnected and tied to clear the rocker-arms. Be careful to put all liners in the strap where they belong. In freezing weather if the fire is drawn, drain all water out of pumps and injectors as well as out of all feed and branch pipes. If there are no frost plugs, slack the joints to let the water out. If there is danger of water freezing in the boiler run it out of both boiler and tank.

BLOCKING CROSS-HEADS.

It is best always when it can be done, to block cross-heads at the extreme back end of the guides. On some eight-wheeled connected engines this cannot be done, as the front crank-pin will not clear the cross-head key. In this case it is best to block them well with piston at front end of cylinder with valve arranged to cover the ports, or to admit steam into the back end of the cylinder, providing the front part of the valve or front steam-port is not broken, in which case steam must be in the front part of the cylinder, and have the valve-stem well clamped. Cross-heads need not be blocked if there is no pressure in the boiler.

ENGINE OFF TRACK.

If engine is in such a position as to leave crown sheet or flues unprotected by water, draw the fire; or if you cannot draw it, smother it with earth or sod, snow or fine coal. Ask head-quarters at nearest telegraph office for assistance.

CLAMPING VALVE STEMS.

A valve-stem can be clamped usually by screwing up the nuts on one side only. Where metallic packing is used in the stuffing boxes, you must wedge the valve rod or tie it in such a position as to bind the valve-stem to prevent the valve moving. You can tell when the valve is in proper position to cover the ports by admitting a little steam into the cylinder and notice that steam does not come out of either cylinder cock on that side.

WATER FOAMING IN BOILER.

Open cylinder cocks. Close the throttle-valve gently until the water settles solid, then try how much water there is in the boiler. Open the surface cock, if there is one. Put pumps and injector to work, if necessary. Open the throttle gently and work the foul water through the cylinder; close the throttle often and try the height of the water. Be very careful in admitting steam into the cylinder, or you will knock the packing down or the cylinder-head out. If the cause of foaming is found to be grease in the tank, flow the tank over when you take water, and if you can get about one-fourth of a peck of unslacked lime put it in the tank. A piece of blue-stone about the size of a hickory nut, put in the hose back of the screen will prevent foaming. This can be had in any telegraph office.

PUMPS WILL NOT WORK.

See if there is plenty of water in the tank and that the tank-valve is connected; open the heater cock a few seconds, then open the pet cock, then close the heater and try the pump, if it will not work then slack down the lower pump joint. If the water flows freely move the engine about a dozen revolutions, then tighten up the joints. *If the water does not flow freely*, the feed-pipe, strainer or hose is choked (inside lining of hose may be torn loose) and must be cleaned out. If the pump will not work when the water flows through the joints, take the lower valves out and see that they are free. If you still find nothing wrong the pump must be repaired at the shop.

PUMPS AND INJECTOR FAIL.

Cover the fire dead. Stop as soon as possible and proceed to examine as directed above; by slacking the lower joint of the pump first, you find at once where the trouble is. If the water flows freely, you will know there is nothing wrong with the tank valve, hose, strainer or feed-pipe, and then by running a few revolutions with the water flowing from the joints you can often wash out any small obstruction from under the lower valve of the pump.

If water gets too low to allow time for examination draw the fire and notify headquarters from the nearest telegraph station. No injector will work well if there is the slightest leak in the feed-pipe, and some will not work at all. A very small spark in the steam nozzle of an injector will prevent its working. If an injector flies off only when the engine is running fast and works well at other times, the hole in the washer at the end of the feed pipe is too large; take it out and try a washer with an inch and a quarter hole in. Always examine and see that the branch pipe is clear.

PROTECT YOURSELF FROM APPROACHING TRAINS.

PUMP CAN BE WORKED WITHOUT PISTON.

If engine is disabled on one side: as long as the main rod, guides and cross-heads are in working order, (if the pump arm is attached to the cross-head), you can work the pump on that side by taking out the piston, leaving the main rod on.

BURST FLUE.

Reduce the steam pressure and plug the flue. A wooden plug will answer if you have no iron plug.

BLOW-OFF COCK BROKEN, OR HOLE IN BOILER FROM ANY CAUSE.

Stop as quick as possible; get fire out at once and notify headquarters from the nearest telegraph station. If desirable, you can make a wooden plug to fit the hole, split it at one end, put it in the hole and drive a wooden wedge in the split, fill your boiler and fire up, and you can go on your way.

WHISTLE BLOWN OUT.

Fit a wooden plug in the hole and secure it with any kind of a lever, wood or iron, using ropes to secure the lever.

THROTTLE-VALVE DISABLED, OR CANNOT PREVENT STEAM FROM ENTERING THE CYLINDER FROM ANY CAUSE.

See that the leak is not caused by the tallow cup, steam cocks being open, if it is not reduce the steam pressure low enough to handle the reverse lever. Then use the reverse lever and brakes, to control the engine. Try to get your train to a siding. Whenever you stop have the reverse lever out of gear and use chocks under the wheels. *If the throttle-valve is disabled so that it cannot be opened*, if the engine has steam chest tallow pipes leading from the cab, you can run the empty engine by using steam from them;

if not, draw the fire and prepare the engine to be towed to the shop. In both cases notify headquarters from next telegraph station.

BROKEN STEAM-CHEST OR BRANCH-STEAM PIPE IN SMOKE BOX BROKEN.

Take out the branch-pipe on that side, bolt a piece of plank against the T head, using a piece of rubber for a joint. Take down the main rod on that side; disconnect the valve-rod, and tie or clamp it to clear the rocker-arm. Leave your train, and run, under light pressure, to next telegraph station and ask for orders.

BROKEN CYLINDER-HEAD, PISTON, MAIN ROD OR STRAP.

Take down main rod on that side. Block the cross-head, disconnect the valve rod, and cover the ports with the valve. Clamp the valve-stem, so that the valve cannot move. Tie the valve-rod clear of the rocker-arm, then you are ready to go with all the train you can handle.

BOTH FRONT CYLINDER-HEADS BROKEN.

If *both front* cylinder-heads are broken and nothing is wrong with piston or valve gear or their connections, an engine can be run by taking off both steam chest lids and fitting blocks of wood in the front steam ports, then replace the lids and you are ready to go with all the train you can haul.

BROKEN ROD SET SCREWS.

If it is required to remove a key from a rod, if the set screw is broken and cannot be backed with a chisel, if in the back end of a main rod, take the strap bolts out of that end of the rod, and block the cross-head; then with a pinch bar move the engine until the key is loose. If the set screw is broken in a paral-

lel rod, take the bolts out of the strap where the screw is broken, block the other drivers and with pinch bars slip the wheels until the screw is loose.

BROKEN CROSS-HEAD.

Take down main rod; disconnect valve-rod on that side. If the piston is broken, cover the ports with valve, clamp the valve-stem, tie the valve-rod to clear the rocker-arm; you are then ready to go with all the train you can haul. If the piston is not broken, push it against the front cylinder-head and block the cross-head. If the cross-head is broken so that it cannot be blocked, take the piston out, or if you cannot take it out push it against the front cylinder-head and arrange the valve so as to admit steam into the back end of the cylinder and clamp the valve-stem well.

BROKEN SMOKE BOX FRONT.

Board it up close, using the front end bolts to hold the boards.

ECCENTRIC, ECCENTRIC-ROD OR STRAP BROKEN.

Take both eccentric rods and strap down on that side. Cover steam-ports with valve; clamp the valve-stem so that the valve cannot move. Take down the main rod and block the cross-head. It is not always necessary to take down the back motion, eccentric-rod and strap, when the forward motion is disabled, but the *link lifter must be disconnected.*

BROKEN VALVE-YOKE OR VALVES DISABLED INSIDE OF STEAM-CHEST.

You can find which side is disabled by getting the cross-head in the centre of the guides on either side; then admit a little steam into the cylinders, and move *the reverse* lever to its extreme points both ways. If *steam does not* come alternately from both cylinder-

cocks on the side that is on half-centre as the reverse lever is moved, that side is disabled; then take off the steam chest lid. If the *valve-yoke is broken* place the valve in the chest so as to cover the steam-ports. Block it with wood at both ends so that it cannot move. Put on the lid, disconnect the valve-rod and tie or clamp it to clear the rocker. Take off the main rod and block the cross-head. The engine is then ready to go with all the train it can haul. *If the valve-stem is broken inside the steam-chest,* take the stem out and plug up the stuffing-box with a wad of waste or packing, using the gland to hold it there. Block the valve and disconnect the same as above.

VALVE BROKEN.

Take the valve out. Lay a piece of inch board with one flat surface on the valve seat. Have the board large enough to cover all the ports. Lay the valve on top of the board, in the centre of the chest; block the board and valve so that they cannot move; leave the valve-yoke out; put on the steam-chest lid; plug up the stuffing-box with a wad of waste or packing, using the gland to hold it there; take off the main rod and block cross-head. The engine is then ready to go with all the cars it can haul.

VALVE-ROD OR VALVE-STEM OUTSIDE OF STEAM-CHEST OR TOP-ROCKER ARM BROKEN.

Take the broken parts off. Cover the ports with the valve. Clamp the valve-stem so that the valve cannot move. Take off the main-rod and block the cross-head. The engine is then ready to go with all the cars it can haul.

BROKEN VALVES-EAT.

Disconnect the valve-rod. *If front port is* broken push the valve back so as to cover exhaust and back

steam-ports. Block the valve so that it cannot move; tie the valve-rod to clear the rocker-arm; take down the main rod and block the cross-head. *If the back port is broken*, block the valve so as to cover the exhaust and front steam-ports; tie or clamp the valve-rod to clear the rocker-arm. Take down main-rod and block cross-head. *If the bridge between the exhaust and steam-ports is broken*, block the valve so as to cover all the ports, then with the main rod off, cross-head blocked and valve rod clear of the rocker, the engine is ready to go with all the cars it can haul.

SADDLE-PIN, LIFTER OR LIFTING-ARM BROKEN.

Take the link-lifter off. Fit a piece of wood in the slot between the top of the link and link-block for the link to rest on, make the block long enough to hold the link as high as you desire to have the engine cut off and tie the block in its place. Run carefully.

BOTTOM ROCKER-ARM BROKEN.

Take down both eccentric rods and straps on that side. Cover the ports with the valve; clamp the valve-stem so that the valve cannot move; take the link off by disconnecting the link-lifter from the lifting arm; take down the main rod and block the cross-head. The engine is then ready to go with all the cars it can haul. (See page 17 of the Reasons Why at the end of this book.)

BROKEN TUMBLING-SHAFT OR REACH-ROD.

Fit pieces of wood in the slots of both links, to hold the link as high as desired. As you cannot reverse, run very carefully, and control the engine with the brakes.

TO FIND AN ENGINE CENTRE.

In case of a slipped eccentric or to find an engine centre for any purpose, get a piece of board 18 to 2c

inches long having one straight edge, get the engine as near the centre by the eye as you can, then lay the straight edge on top of the back end of main rod strap, allowing it to project as far as the main driving axle; then move the engine until the outer edge of the axle will show an equal space when the straight edge is pressed against the bottom of the strap as it shows when on top of the strap. You will then have the engine on its dead-centre. If you have a pair of dividers scribe a circle the exact size of the strap, around the driving axle, then move the engine until the straight-edge shows that the strap is in line with the circle from the top and bottom of strap.

SLIPPED ECCENTRIC.

On engines having rock-shafts, *the eccentric always follows the crank pin in the direction that the Engine is moving;* for example, if the engine is on its forward centre, the forward motion eccentric should be upwards and the back motion downwards, each inclining a little ahead, so you can always tell if an eccentric is out of place by its position with the crank-pin on its own side. If you find that an eccentric has slipped, get the engine on forward centre, and if for example, forward motion eccentric is slipped, put the reverse-lever in extreme back notch; mark the valve stem close to the gland, then put the reverse-lever in extreme forward motion notch and turn the loose eccentric until the mark on the valve-stem comes to the place where it was made; then secure the eccentric with the set-screws. Be sure that the full part of one eccentric is above the crank and the full part of the other is below the crank. Both eccentrics must not be in the same position on the axle. Use the forward centre for setting either back or forward motion eccentrics.

LAP AND LEAD OF VALVES.

When an Engine is on its dead centre, if the valve shows that the steam port is open the size of the opening is called the outside lead, the difference of the distance between the out edges of the steam ports and the length of the valve, gives the amount of outside lap. For example: If one steam port is one inch, the bridge 1 inch, then the exhaust port 2½ inches, then the other bridge 1 inch, and last the other steam port 1 inch, it makes altogether 6½ inches; now suppose the valve to be 8 inches long, it has 1½ inches *whole* outside lap; to get the lead on the exhaust measure from the inside edge of one steam port to the outside edge of the other steam port, which includes both bridges, the exhaust port and one steam port, substract this distance from the space on the valve, measuring from the out edge of the valve to opposite edge of the cavity in the valve, including the cavity. For example: Suppose the exhaust port to be 2½ inches, each bridge 1 inch, making 2 inches more, and one steam port 1 inch making altogether 5½ inches; now suppose the cavity of the valve to be 4½ inches, and one edge of the valve to be 1¾ inches, you have altogether 6¼ inches; subtract the 5½ inches and you have ¾ of an inch, which is the amount of lead on the exhaust.

LAME EXHAUST AND SETTING SLIDE VALVES.

An engine may become lame in the sounds of its exhaust in four ways: 1st—The valves may need dividing. 2d—An eccentric or strap or some of the valve-gear may become loose. 3d—One exhaust nozzle may become choked or closed smaller than the other. 4th–A main-rod may have been lined too long or too short; in either of these cases an engine will not *beat square*. The quickest way to divide valves, is by

the sound of the exhaust. Watch the cross-head and if a heavy beat occurs as it comes near the back centre, shorten the eccentric rod. If the heavy beat is on the front centre, lengthen the eccentric rod. This rule applies to forward or back motion. Do not lengthen or shorten more than a sixteenth of an inch, this may be too much or too little—a few exhausts will tell you. Another plan is to move the engine over its centres and make a mark on the guides at both centres and at the exact point at which the cross-heads stop; then open the cylinder cocks and move the engine until steam begins to come from one of the cocks; then measure the distance that the cross-head has traveled from that centre. If steam came from front cylinder-cock measure from front centre, then move the engine in the same direction, (having the reverse lever always in the same notch) until steam begins to come from the other cylinder cock (on the same side,) and measure the distance traveled from that centre. If the distance traveled from the front centre is greater than that traveled from the back centre, shorten the eccentric-rod; but if the distance traveled from the back centre is greatest, lengthen the eccentric-rod; then try the measurements on the cross-head again and lengthen or shorten the eccentric rod until the distances traveled by the cross-head are equal. (It will answer the same purpose if the engine is moved until it gets to the exact points at which the steam *ceases* to come from the cocks instead of the points at which it *begins* to come.) Always move the engine ahead to set forward motion and back for back motion. This rule also applies to forward or back motion, and both rules apply only to engines having rock-shafts. If the engine has no rock-shaft use the words lengthen for shorten, and shorten for lengthen the eccentric-rods in both rules.

DIVIDING VALVES WITH LIDS OFF.

Find and mark on the guides the exact points at which the cross-heads stop at both ends of the guides, examine the eccentrics and see that they are in proper position on the axle; that is when the engine is on its front centre (if the Engine has rock-shafts) the full part of the forward motion eccentric is upward and the back motion downward. Then put the reverse lever in the notch where the engine is usualy worked, say the 4th from the front. *The engine is now on its forward centre.* Now bar her ahead (or move her with another engine.) As the engine is moved the valve will move back for a while and then return, then as soon as the front edge of the valve is just even with the front edge of the steam-port, stop moving the engine and measure from the mark you made on the front end of the guide to the front edge of the cross-head Note this measurement, Let us suppose it was 11 inches; now move the engine until the back edge of the valve is just even with the back edge of the back steam port, then measure the distance that the cross-head has moved from the mark made on the back end of the guides. We will suppose this to be 13 inches, which shows that the valve did not move far enough back, consequently the eccentric rod must be lengthened (or the valve-rod shortened) to cause the valve to cut the steam off when the cross head has moved 12 inches from each end of the stroke, then divide the other valve in the same manner, put the reverse lever in a similar notch, (say the 4th from the back) and divide the back motion, moving the engine backward. Pay no attention to full stroke, that will be all right if they show right in the fourth or any of the other notches. If the Engine has no rock shafts use the words shorten for lengthen and lengthen for shorten in this rule.

BROKEN PARALLEL-ROD OR STRAP.

Take it off; also the rod on the opposite side. If a back rod on a six-wheel connected engine breaks, only the back rods need come off. If the front parallel rod is broken, all the parallel rods must come off on both sides. You can run with main rods but must leave your train and notify headquarters at next telegraph station.

SPRING OR SPRING-HANGERS BROKEN.

If driving spring or hanger, take it out. Jack the engine up behind; pry up the low end of the equalizer until it is level and block with hard wood. Take out the spring-saddle and block with hard wood between the driving box and frame. If you have no jacks, block up close on the tops of *all* the driving boxes using nuts or washers, and run the pair of wheels that have broken springs on wedges or blocks of wood; this will ease the strain on the good spring, and you can then pry up the equalizer and block it, then remove the wedges from under the drivers and run the wheels with good springs on the wedges. This will give space to put a block on top of the driving box with the broken spring, then run the engine off the wedges, remove the nuts from the tops of the driving boxes and you are ready to go.

BROKEN CRANK-PINS.

If *main crank-pin breaks*, take off main rod on that side and all parallel-rods on both sides. Block the cross-head; disconnect the valve-rod on that side; cover the ports with valve; clamp the valve-stem and tie the valve-rod to clear the rocker. Leave the train and run with one main rod to next telegraph station and report condition of engine If a front crank-pin is broken, take off all parallel-rods; leave the train and run to next telegraph station and report. If back

crank-pin is broken, take off both back parallel-rods and then you are ready to go on.

BROKEN EQUALIZER.

Take it out, also the springs to which it is attached. Jack that side of the engine as high as the other side: take out the spring-saddles (if you can) and block up close with nuts and washers on the tops of the driving boxes where the broken equalizer was. If you have no jacks, block with nuts on top of all driving boxes; move one pair of drivers that has no spring over it on to wedges or blocks, and block with hard wood on top of the driving box that has wheels resting on the rail; then remove the wedges and place them under the other driving-wheels. Move the engine on them and block on top of the other driving box. Remove the wedges and all nuts used for blocking on the other boxes, and you are ready to go.

TIRES BROKEN.

If main tire, send by nearest telegraph station to head-quarters for assistance.

FRONT TIRE.

Run the wheels with broken tire on blocks or wedges to raise them high enough to clear the rail. Take out the oil cellars; put blocks of wood between the axle and pedestal caps; slack the front parallel-rod keys. You need not take side-rods off. Run slow.

BACK TIRE.

See item special cases of broken tires on page 24.—Take off both back parallel rods; run the wheels on wedges or blocks high enough to clear the rails; take out the oil cellars, and block with wood between the axle and pedestal caps, leave the train and *run slow to next* telegraph station and ask for orders.

ENGINE TRUCK WHEEL OR AXLE BROKEN.

Jack it up clear of track and chain it there, then run very slowly, especially over frogs, to next siding, and send word to head-quarters from nearest telegraph station.

FLANGES OF WHEELS BROKEN.

Run very slow especially over frogs.

DRIVING AXLES BROKEN.

If front driving axle on a six-wheel connected engine or back driving axle on a four-wheeled connected engine is broken.

Take off all parallel-rods; if axle is broken *outside of the driving box* remove the wheel that is broken off, and block up the axle from the pedestal cap; see that the axle is parallel with the other axles and allow the good wheel to rest on the rail. If the axle is broken *inside of the driving box*, so that the wheel cannot be removed, raise the wheels with broken axle to clear the rails and block them from the pedestal caps. You must leave your train and move very slowly and cautiously to next telegraph station and notify head-quarters.

Back driving axle on a six-wheel connected engine Broken.

If axle is broken outside of box remove the wheel that is broken off: take off both back parallel-rods, block up the axle from the pedestal cap as near parallel with the other axles as possible, allow the good wheel to rest on the rail, leave the train and run slowly to next telegraph station and report. If the axle is broken inside of the bearings take off both parallel-rods, raise both wheels to clear the rails, blocking from the pedestal caps and proceed without train.

Main Driving Axle Broken.

If broken *outside of driving box*, take off all parallel-rods, remove the wheel that is broken off, take off main rod, block cross-head, disconnect valve rod, and

cover ports with valve and clamp valve-stem on disabled side; block up broken end of axle from pedestal cap; leave the train and move engine very slowly to next telegraph station and report to head-quarters. If main driving axle is broken *inside of driving box*, all you can do is to report to head-quarters from nearest telegraph station, and prepare the engine to be towed.

Special cases of broken tires and bent and broken driving axles

In some cases driving axles cannot be supported from the pedestal caps, as for example: The rear drivers of a Mogul Engine. In all these cases disconnect the Engine the same as directed above, then get a piece of timber or rail road bar about the length of the axle and run it through between the arms or spokes of the wheel, catching both wheels on that axle; this of course will prevent them from turning. Then if your main axle is not disabled, you can run your Engine to the nearest siding with the wheels sliding and ask head-quarters for orders from the nearest telegraph station.

TENDER WHEEL OR AXLE BROKEN.

Lay a piece of timber (a railroad bar of proper length or a cross tie will do,) across the top of the tank on the apron; put blocking under the timber so that the apron may not be damaged; jack up the broken wheel or axle and chain both ends of the truck to the timber to hold the wheels clear of the rail.

ENGINE BLOWING.

An engine may seem to be blowing if the exhaust nozzles are badly choked, but if an engine blows *only while passing its centres*, something is wrong with the packing in the cylinder. For example: if the right side packing is slack the blow will occur while the engine is passing both front and back centres on the right side. If the blow occurs while passing over one

centre only, and does not blow while passing over the other centre on the same side, there is a hole in the follower or spider on that side, or if steam-packing is used in the cylinder, one of the rings is broken, in which case steam will come from both cylinder-cocks on that side while the cross-head is passing the blowing centre. If steam does not issue from both cocks at that point the blow is on the other side of the engine and is either a broken valve or valve-seat, a loose valve-seat or a hole or crack in one of the steam-port bridges. If an engine blows constantly while in motion, the trouble is in the valves or steam-pipes. If *while an engine is working*, steam comes at the same time from both cylinder-cocks when the upper arm of the rock shaft is perpendicular, the valve is blowing on that side. It may need facing, or sudden heavy reversing may have caused it to *become cocked* or to stick fast in its yoke, in which case take out the steam-chest tallow cup and with a punch drive the valve down; or the reversing may have bent the valve-stem, and if a valve-stem is bent only a little the valve will blow under a light throttle, but may not blow while the engine is pulling heavy. If an engine is standing, steam will not come from the cylinder-cocks on the side that has the ports covered, even if the valve does blow. *Unless the engine is moving*, the steam will pass directly through the exhaust up the stack. A leaking steam pipe makes a noise like a blower, sometimes caused by joints becoming loose. If you have any doubt about which side the engine is blowing, open the smoke box door and give her a little steam, you can then see which exhaust-pipe the steam comes from, which will show the side that is blowing. Then if you have any doubt about whether it is valve or packing, get the engine at half-stroke, take off the front cylinder-head and arrange the valve to admit

steam back of the piston, you can then see if the steam comes from the steam-port or packing.

SETTING UP WEDGES.

Do not be deceived and think wedges are slack when running on a rough road, when the ground is frozen solid. Engines should have steam up to have wedges adjusted. Get the engine on a level and straight track, then get her at half-stroke on one side *with crank-pin upward;* then block the wheels on the other side, so that when the engine is moved against the blocks the driving boxes will press the shoes, leaving the wedges free; move the engine against the blocks, and slack all the side-rod keys. Be sure that the rods are all loose, that there is no steam in the cylinder, and that the axles are parallel with each other. You must use a tram to find this out. Then set up all the wedges on the side that is on half centre; screw them up solid, and make a mark on the pedestal. Then draw them down until in your judgment they are free enough, usually about one-eighth of an inch. If there is any lost motion in the wedge bolt, fit pieces of hard wood between the wedge and pedestal cap and draw the wedge down solid on them. Then get the engine on half-stroke on the other side. Use every wedge in the same manner. Don't forget to jam the lock-nuts. You will then want to *key the side-rods.* To do this, get the engine on its parallel centre and key that side, beginning at the main pin. Be sure that the other ends of the rod are free. Do not key too tight. Remember that the engine is on a straight track, and when it gets on a curve the rods will be cramped, and if you do not give them play, they will take it and probably hot pins or cut brass will be the result. After keying the main pin brasses, *key the back end*, then on a *six-wheel connected engine*,

key the front end. On an *eight-wheel connected engine*, key the front pin last, then place the engine on its parallel centre on the other side and key that side in the same manner. Then move the engine on the other centres opposite to those on which they were keyed and see that the rods are free. •It is well also to try them on quarter centres, as on old engines the pins are apt to be worn out of true. Leave your side rods free —it is no injury to have them rattle a little, especially if the driving boxes are well worn. It takes power away from the engine if side rods are snug. Key the *back end of a main-rod on centre*, and be sure you have all the steam out of the cylinder. Key the front end of a main-rod on the down half centre, and no steam in the cylinder.

FILING AND LINING ROD BRASSES.

Do not file one pair of side-rod brasses, without examining all of the others; do not have one pair loose and the others snug—all should be filed and lined alike. Use calipers and a flat surface of some kind. Caliper the brasses between the edges to be filed and the back of the brass. File until both edges caliper alike, then test the edges filed on some flat surface; if the brass rocks, file the high places until the brass is true. Only file a little at a time and try it often with calipers and flat surface. Brasses do not always need filing when they knock, sometimes they do not fit the strap, when a thin liner can be put between them and the strap. Do not file enough off any brass so that keying will make them tight on the pin on which it runs. Put the brasses in the strap and try them on the pin without the rod; if they will not turn easily on the pin when keyed solid, they are filed too much and should be lined between their edges. In lining up rods put all the liners in with the brasses that is pos-

sible to get in; put in one thick liner in preference to a number of small ones. If it is necessary to put thick and thin liners on the key side of the brass put the thick liner next to the key. If rod brasses that have been running well take to heating, clean and oil them well, but do not file the bearings.

In lining main rod brasses, first be careful to look for marks on the guides showing how much the piston clears the cylinder-heads, and see that the clearance is equal on the front and back; get some one to move the engine very slowly while you watch the cross-heads as they approach the ends of the stroke, then line so as to make the clearance equal at each end.

TO LINE PARALLEL ROD-BRASSES.

Get the engine on a level and straight track, and on its parallel centre—that is the centres of the axles and the centres of the crank-pins—all in a line parallel with and the same height from the track; then begin at the main pin and divide the liners so that the brasses and liners together, are of equal thickness in front and back of the pin; then put up that end of the rod, draw the bolts solid and adjust the key. Then prop up the back end of the rod level with the back pin entering the front brass; fill up the space between the end of the rod and the brass with liners; then put on the back strap with brass; put the bolts in, draw them solid and key the back brasses. On a six-wheel connected engine, begin at the main pin, then put up the front end leaving the back brasses to the last. No tram is needed to line up rods. All parallel rod brasses should be lined and keyed on the parallel centre. There is no occasion to tram pin centres. If the hub centres are in tram, and the engine is lined on the parallel centres the pins must come right *unless they or the axles* are bent.

CYLINDER PACKING.

You can tell on which side packing is out of order by watching the cross-heads. If the blow occurs immediately after passing the centres that side packing is slack or out of order. To set it out, get the cross-head close to the end of the stroke on the front centre, say about half an inch before it arrives at the end of the stroke, moving the engine ahead. You can then cover the ports with the valve on that side and keep steam out of that cylinder; then take off the cylinder-head and follower, make a mark on the cylinder-head; also, on the follower before you take them down, so that you can put them up to the same places. (Sometimes the holes only suit one way). Be careful to lay the cylinder-head nuts, and follower bolts in such a manner when you remove them that you will be able to put them back where you found them. Then with a pair of inside calipers or stick of proper length, get the piston in the centre of the cylinder, pressing the packing only enough to lay against the cylinder; then jam the nuts. After the jam nut is fairly against the other nut, use two wrenches and jam as much back on one nut as ahead against the other, or you will make the packing too tight; then tap the springs with a hammer and see that they are only reasonably snug—be sure that the packing lays against the cylinder all around; if it does not the packing should be taken out and the cause ascertained and remedied, if possible. After the packing is set out, clean off the follower and put it on; see that the heads of the follower-bolts press the follower and that their ends do not touch bottom, then clean the cylinder-head joints and put the head on. In screwing up follower bolts and cylinder-head nuts, be sure to get them solid; use judgment, especially in screwing the cylinder-head nuts or you will break the studs. When the head is put on, see that

the joints lay close together all around, then put the top nut on and run it on until it just comes against the head, then put the bottom nut on in the same manner, then a nut on each side and draw them watching that the joints are together all around, then put on all the nuts and draw them equally all around the head. You will sometimes find after removing the follower that the packing is not slack, although it seemed so before the follower was taken off; this shows that the packing was clamped and held by the follower and that the packing is too long—it was follower-bound. This can be remedied by placing a piece of wrapping paper between the follower and spider; or the packing may be too short, in which case a piece of wrapping paper may be placed between the packing rings. Packing does not need setting out of if it blows only a little at starting—you rob the engine of its power by having it too tight. It should not be snug enough to prevent an engine drifting freely. Packing should not be allowed to run longer than two months without being examined.

KNOCKS AND THUMPS.

If you wish to find a thump on an engine, get it in position with *crank-pin upward* on that side, block the drivers front and back and get some one to give her a little steam and by moving the reverse lever ahead and then back several times you can find the defective part. The most deceiving of *knocks* to find on an engine is when a spider is loose on the piston-rod, or cylinder packing is too short—that is when it does not fit between the spider and followers. These knocks have deceived many old runners: they have supposed them to be caused by loose wedges, driving-box crown brasses, cross-heads, main rod brasses, &c. Loose *spiders, or short* packing, can be detected by a slight

blowing accompanying a *sharp click* while the engine is passing centers. If the spider is loose on the piston-rod the sharpest knock will occur while passing the front centre. The noise is similar to that made by a cross-head being loose on a piston-rod. These knocks generally come suddenly and sound as if there was an inch play somewhere when the motion is only really as much as a single thickness of tissue paper. If a driving box wedge has not the proper taper it will cause a thump while engine is passing the back centre. It is useless to try to make such a wedge work right until it is planed to suit the box. These defects can be properly remedied in the machine shops only. All *knocks* are in pistons, cross-heads, or connecting-rods. Side rod knocks are lighter than any of the others. *Thumps* are caused by loose wedges or driving boxes, loose or cracked pedestals or frames. There is quite a difference between a *knock* and a *thump*.

AIR PUMP DISABLED.

If air pump fails, disconnect the pipe leading from the air pump to the reservoir; then try the pump. If it will *not work* something is wrong with the steam-valve. The small packing rings may be broken or may stick in their cylinders, or some of the small steam or exhaust passages may be choked, the end of the exhaust pipe may be full of sparks. If the pump does work when the air pipe is disconnected, and will not work when the pipe is connected, that pipe or the check-valve may be choked with ice or gum. In cold weather if the pump will not go to work hold a lighted torch to the check chamber and along the air pipe; you can often start them in that manner; examine the screen where the pump receives the air and see that it is clear. If air escapes from a brake cylinder in freez-

ing weather, it may be caused by the packing being frozen, or if the brakes fail to act, there may be ice in the triple valve. Try holding a piece of lighted waste under them. If a pump works well only one way, something is wrong with one of the air valves, or if it works well both ways and gauge does not show sufficient air, there is an air leak somewhere; if you can not find the leak anywhere else, lock the air in the pipe and see if air does not come from the governor exhaust pipe, the diaphragm may be cracked.

CAUSES OF CUT WHEEL FLANGES.

If one side of an Engine is lower than the other, the wheel flanges will cut on the low side. If the driving axles are not square or at right angles with the cylinders, or if they are not parallel with each other, the wheel or wheels that are too far back will cut its Flanges. Cut Truck Flanges on an Engine shows that the Engine is not in the centre of the truck, the front of the Engine should be moved toward the cutting side. An Engine not being in the centre of the truck may also cause the Front driving wheel Flange to cut on the side opposite to which the truck flanges are cutting.

EXTENDED SMOKE BOXES.

If an Engine having an extended smoke box and diaphragm, burns the fire too hard at the front of the fire box, the apron on the diaphragm should be raised; or if the fire does not burn well and the inside of the fire door becomes black, the draught is choked either by stopped up flues, or the apron is too low. When an Engine has proper draught the inside of the fire-door becomes white while running.

CONVEY OR DRAUGHT PIPE.

If an Engine burns the fire more at the back than

the front of the fire box the draught pipe is too low; if there is a sleeve on the pipe raise it; if the fire burns most at the front of the fire box the pipe is too high. If an Engine tears the fire the exhaust nozzles may need cleaning, or they may be too small.

CARRYING WATER.

In running, carry the water in the boiler at as uniform height as possible. Engines rarely steam well when boilers are pumped full then allowed to run low in water, besides such pumping is wasteful of fuel and destructive to flues; a good runner will feed the boiler so that the height of the water will not vary. Never use pumps or injector if it can be avoided unless you have a bright fire. On approaching a grade, always try to have a good supply of water in the boiler, and if you have to apply pump or injector on a descending grade, be sure to have a bright fire. If you have no occasion to supply the boiler on a descending grade, level the fire and cover it, or arrange it so that the pressure of steam will not increase.

CYLINDER LUBRICATORS.

If cylinder lubricators do not feed properly, open all the cocks and take the cap off the lubricator while the engine is drifting without steam; this will draw air through them and clean them out.

OILING.

In oiling an engine do not fail to oil the *sides* of all boxes and bearings; hot boxes and bearings are often caused by neglecting this. *Hot boxes* are mostly caused however by the sponging settling away from the journals. Oiling on top of a box will be of little benefit unless the sponging presses the journal from the oil cellar. All rod and guide oil cups should be taken out and cleaned every week. If an engine is

low on one side it may cause the back end of main rod brasses to heat or cross-head to work badly on that side.

WHAT AN ENGINEER SHOULD ATTEND TO BEFORE LEAVING AN ENGINE HOUSE.

When an engineer is required to take an engine out, he should try how much water is in the boiler, and see that the fire is in good condition. Examine every part of the engine and tender, to see that nothing is broken. Test the rod-keys; don't depend on set-screws; try to drive every key back with a soft hammer; examine every bolt and nut; test the brakes; see that they apply and release easily—especially if using automatic or air brakes. See that you have a good supply of fuel and a tank full of water; all necessary tools, especially for firing, and that *all* lamps and signals are in good order and ready for immediate use; and that there is sufficient oil and tallow and a box full of sand. You should also have a pinch-bar and a pair of jacks in good order. If you have no jacks get four wedges of oak, about three feet long, four inches square at one end, tapered to an edge one way at the other end. You should also have an axe and blocking for cross-heads, and a hand saw.

STARTING A TRAIN.

In starting a train, always have the reverse lever in extreme full throw, never cut back; after the train is well under way cut back one notch at a time; cut back as far as circumstances will permit, run with throttle wide open; you save steam better by cutting back with the reverse lever, *if the notches in the reverse rack are close together*, than by closing the *throttle*, and if drifting without steam, place the

reverse lever at full stroke allowing the valves to have full travel.

HINTS TO FIREMEN.

In firing soft coal do not carry a heavy fire. If the fire is clean and the Engine will not steam with a light fire, your front ash pan damper is too wide open. Two shovelfuls at a time is enough if put on the bright spots; leave the door open *little way for a few seconds* after putting in coal. It helps to consume the smoke; don't use a slash-bar, if you can avoid it. Hook the fire lightly. being careful not to mix it, or get green coal on the grates. If the fire box has an arch, keep a good space open between the arch and fire. If the engine has a heavy train, you will need a heavier fire than with a light train and fast run; always make your calculations to fire according to train and speed. Hook out all clinkers from the fire as soon as you find them, and you will save yourself labor. Do not fire much while pumps or injectors are on full. Do all you can to assist the engineer and do nothing without first obtaining his permission. Keep all tools and cans clean. Help him to oil, and at all work that he is doing; be on hand ready and willing to aid him, and learn what he does and how he does it, trying always to anticipate his wishes. Keep the ash-pan clean or you will burn out the grates. If firing an engine, hauling passengers, put the blower on lightly, and open the fire door a little on approaching a station, as soon as the throttle is closed.

THE WESTINGHOUSE AUTOMATIC BRAKE WITH OLD STYLE TRIPLE VALVE.

The Westinghouse Automatic Brake consists of the following essential parts:

The steam engine and pump, which produce the compressed air; *the main reservoir*, in which the compresed air is stored; *the engineer's brake valve*, (some engines have a three-way cock instead of a brake-valve,) either of which regulates the flow of air from the main reservoir into the brake pipe for releasing the brakes, and from the brake pipe to the atmosphere for applying the brakes; *the main brake pipe*, which leads to the main reservoir to the three way cock or engineer's brake valve and thence along the train, supplying the apparatus on each vehicle with air; *the auxiliary reservoir*, which takes a supply of air from the main reservoir, through the brake pipe, and stores it for its own use on its own vehicle; *the brake cylinder*, which has its piston rod attached to the brake levers in such a manner that, when the piston is forced out by air pressure the brakes are applied; *the triple valve*, which connects the latter to the brake cylinder, and is operated by a sudden variation of pressure in the brake pipe (1) so as to admit air from the auxilliary reservoir to the brake cylinder, which applies the brakes, at the same time cutting off the communication from the brake pipe to the auxiliary reservoir, or (2) to restore the supply from the brake pipe to the auxiliary reservoir, at the same time letting the air in the brake cylinder escape, which releases the brakes; *the couplings*, which are attached to the flexible hose and connect the brake pipe from one vehicle to another.

The automatic action of the brake is due to the construction of the triple valve, the primary parts of which are a piston and a slide valve. A reduction of pressure in the brake pipe causes the excess of pressure in the auxilliary reservoir to force the piston of the triple valve down, moving the slide valve so as to allow the air in the auxiliary reservoir to pass di-

rectly into the brake cylinder and apply the brakes. When the pressure in the brake pipe is again increased above that in the auxiliary reservoir the piston is forced up, moving the slide valve to its former position, opening communication from the brake pipe to the auxiliary reservoir and permitting the air in the brake cylinder to escape, thus releasing the brakes.

These parts are all shown in the accompanying illustration in the pocket of this book, the arrangement being substantially as used on the train.

Thus it will be seen that *any reduction of pressure on the brake pipe applies the brakes*, which is the essential feature of the automatic brake. If the engineer wishes to apply the brakes he moves the handle of the engineer's brake valve to the right, which first closes a valve retaining the pressure in the main reservoir and then permits a portion of the air in the brake pipe to escape. To release the brakes he turns the handle to its former position, which allows the air in the main reservoir to flow into the brake pipe, restoring the pressure and releasing the brakes. A valve called the *conductor's valve*, is placed in each car with a cord running the length of the car, and any of the train men by pulling this cord, can open the valve, which allows the air to escape from the brake pipe. Should the train break in two, the air in the brake pipe escapes and the brakes are applied to both sections of the train; and should a hose or pipe burst, the brakes are also automatically applied.

The guage shows the pressure in the main reservoir and brake pipe when they are connected, and the pressure in the brake pipe alone when the main reservoir is shut off by the movement of the engineer's brake valve.

The *drip cup* is placed in the pipe on the tender to catch any moisture which may collect.

PROTECT YOURSELF FROM APPROACHING TRAINS.

The diagram above the engineer's brake valve shows the various positions of the handle for applying the brake with any desired degree of force, for releasing the brakes, and the position in which the handle is to be kept after the brakes have been released.

HOW TO APPLY AND RELEASE THE WESTINGHOUSE AUTOMATIC BRAKE.

These brakes are applied when the pressure in the brake pipe is suddenly reduced, and released when the pressure is restored.

It is of great importance that every engineer should bear in mind that the air pressure may sometimes reduce slowly, owing to the steam pressure getting low, or from the stopping of the pump, or from a leakage in some of the pipes when one or more cars are detached for switching purposes, and that in consequence it has been found absolutely necessary to provide each cylinder with what is called a leakage groove which permits the air pressure to escape before the brake is applied, thus preventing the application of the brakes when the pressure is slowly reduced as would result from any of the above causes.

This leakage groove is a semi-circular groove, nine sixty-fourths of an inch in width and five sixty-fourths of an inch in depth cut in each car cylinder, and extending so that the piston must travel three inches before the groove is covered by the packing leather. A small quantity of air, such as results from a leak, passing from the triple valve into the car cylinder, has the effect of moving the piston slightly forward, but not far enough to close the groove, which permits the air to flow past the piston. If, however, the brakes are applied in the usual manner, the piston will be moved forward notwithstanding the slight leak, and cover the groove. It

is important that this groove shall be three inches long and shall not exceed in area the dimensions given above.

These provisions against the accidental application of the brakes must be taken into consideration, or else it will sometimes happen that all of the brakes will not be applied when such is the intention, simply because the air has been discharged so slowly from the brake pipe that it only represents a considerable leakage, and thus allows the air under some cars to be wasted.

It is thus very essential to discharge enough air in the first instance, and with sufficient rapidity, to cause all of the grooves to be covered, which will remain closed until the brakes have been released. In no case should the reduction in the brake pipe for covering the grooves, be less than four or five pounds, which will move all pistons out so that the brake shoes will be only slightly bearing against the wheels. After this first reduction the pressure can be reduced to suit the circumstances.

On a long train, if the three-way cock be opened suddenly, and then quickly closed, the pressure in the brake pipe, as indicated by the gauge, will be suddenly and considerably reduced on the engine, and will then be increased by the air pressure coming from the rear of the train ; hence it is important to always close the three-way cock slowly, and in such a manner that the pressure as indicated by the gauge will not be increased, or else the brakes on the engine and tender, and sometimes on the first one or two cars, will come off when they should remain on. It is likewise very important, while the brakes are on, to keep the three-way cock in such a position that the brake pipe pressure cannot be increased by leakage from the main reservoir, for any

increase of pressure in the brake pipe causes the brakes to come off.

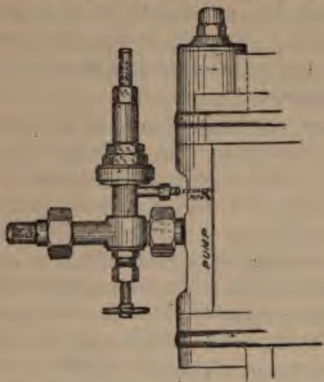
On long down grades it is important to be able to control the speed of the train and at the same time to maintain a good working pressure. This is easily accomplished where the driving wheel brakes are not operated independently of the train brakes, by running the pump at a good speed, so that the main reservoir will accumulate a high pressure while the brakes are on. When, after using the brake some time, the pressure has been reduced to sixty pounds, the train pipes and reservoirs should be recharged as much as possible before the speed has increased to the maximum allowed. A greater time for recharging is obtained by considerably reducing the speed of the train just before recharging and by taking advantage of the variation in the grades. Where the driving wheel brakes are used independently of the train brakes, it is unnecessary to reduce the speed of the train, as these brakes can be held on and will hold the train, while the brakes on the train are being released to recharge the reservoirs,

PUMP GOVERNOR.

This governor should be connected to the stud in the side pipe of the pump, with the throttle-valve end of the governor turned downward, which will prevent its being closed by the shaking of the engine. Provision is made by the Westinghouse people for attaching the governor in this way, and when so attached, the upper end of the governor must in all cases be connected to the train pipe. The illustration on page 41 will show clearly how this governor should be connected.

This governor is for regulating the speed of the pump. It is set for a certain pressure, say 70 pounds,

and when the pressure in the train pipe gets below that at which the governor is set, the steam-valve of the governor is opened and the pump increases its



speed, and raises the pressure to the desired point. When the brakes are applied the reduction of pressure in the train pipe opens the steam-valve, and the pump rapidly produces a surplus pressure in the main reservoir which insures the quick release of the brakes. When the governor is running, the throttle-valve should be wide open. Should the governor leak around the throttle, repacking is needed.

There should not be any safety-valve or leaks in the main reservoir, otherwise the necessary surplus pressure for quickly recharging cannot be obtained.

To release the brahes with certainty it is important to have a higher pressure in the main reservoir than in the main pipe. If an engineer feels that some of hisbrakes are not off, it is best to turn the handle of the three-way cock just far enough to shut off the main reservoir and then pump up fifteen or twenty pounds extra, which will insure the release

of the brakes; all of which can be done while the train is in motion.

For ordinary stops, great economy in the use of air is effected by, in the first instance, letting out from eight to twelve pounds pressure, while the train is at speed, taking care to begin a sufficient distance from the station.

The pump should be run constantly, but never faster than is necessary to maintain the required air pressure; 50 or 60 pounds pressure for low speed trains and from 70 to 80 pounds pressure for fast trains; for *ordinary stops* the brakes should be applied lightly by allowing a gradual escape of air from the train pipe, closing the cock gently when the pressure has been reduced from 4 to 8 pounds on the gauge. The brakes are fully applied when the pressure shown on the gauge is reduced 20 pounds; any further reduction is waste of air. The amount of air discharged from the train pipe should *vary with the speed of the train to be stopped*. Too much care and moderation cannot be used in applying the brakes for ordinary stops; by applying them at a fair distance from the station with moderate force, the train is stopped gently,—while if thrown on suddenly the train is jerked and wheels are often ruined and brake gear damaged. Engineers should remember that *the same amount of braking force cannot be used at both high and low speeds*. A force which is apparently very moderate at high speed will slide wheels at a slow speed—the brakes should be thrown off as the train is coming to rest. In releasing the brakes the handle of the brake valve should be moved quite against the stop and be kept there about ten seconds and then moved back against the intermediate stop, which is the feed position, and where it must remain *while the train* is running. Engineers, upon finding

that the brakes have been applied by the train men or automatically, must at once aid in stopping the train by turning the handle of the brake valve towards the right. If three-way cock is used instead of a brake valve close it and leave it closed until the defect is remedied; meanwhile allow the pressure to accumulate in the main reservoir, so that the train-pipe and auxiliary reservoirs can be charged when required.

THE WESTINGHOUSE AUTOMATIC QUICK ACTING AIR BRAKE

consists chiefly of a special triple valve, acting in conjunction with a special Engineer's Brake valve. These two valves are so arranged that two kinds of stops can be made; first an ordinary or what is known as a service stop; second a sudden or what is called an emergency stop. These different stops are accomplished by having the brake valve so arranged that the full pressure of air in the main reservoir is not admitted into the auxiliary reservoirs. If the full pressure was used for ordinary stops the brake gear and wheels would be apt to suffer, so this extra pressure is kept in the main reservoir to use, when sudden stops are required. The pressure in the main reservoir is shown by the red pointer on an air gauge having two pointers, one red, the other black. The pressure in the auxiliary reservoirs is shown by the black pointer; the difference should show from twenty to twenty-five pounds. The extra pressure is also utilized for releasing the brakes as well as for charging the train quickly. The new brake valve is also connected with an equalizing air reservoir, the object of which is to regulate the pressure of air in the train and prevent too sudden discharge of air from the front part of the train. This feature of the new valve overcomes the difficulties in reference to

handling long trains, experienced by the use of the three-way cock mentioned on pages 39 and 40 of this book. The new triple valve can be used with the old automatic brake, but can not be changed to straight air.

INSTRUCTIONS FOR HANDLING THE WESTINGHOUSE QUICK ACTING AUTOMATIC AIR BRAKE.

One of the most important duties of an engineer is to see that this brake is in good working order by trying it before leaving the engine house.

(See diagram marked plate D. 2., in the pocket of this book.)

Air should be pumped into the main reservoir until the red pointer, on the air gauge, shows about ninety pounds. After coupling, you are ready to CHARGE THE TRAIN, by placing the handle of the brake lever to "*release position*" and allow it to stay there until the black pointer shows about seventy pounds of pressure, then turn the handle to "*service stop*" position until the brake tests, (as stated on pages 47, 48 of this book), are made, then turn the handle to "*running position.*" You are now ready to go. If you wish to slow up place the handle "*on lap*" position for a second or two, then if you wish to make an ordinary stop, move the handle to "*service stop*" position, until you have reduced the pressure shown by the black pointer about eight pounds; then turn the handle back to "*on lap*" position, and leave it there until the train is nearly stopped; then turn the handle to "*release position,*" except on grades, and leave it there until the brakes are entirely off; then return the handle to "*running position.*"

If while running you have reason to suspect that brakes are not fully released, move the handle of the brake lever to "*release position*" for about a minute, *then turn it back to "running position."*

PROTECT YOURSELF FROM APPROACHING TRAINS.

When moving long trains on down grades have the brake handle in "*release position*," at all other times while running have the handle in '*running position.*'

Do not use air after having called for hand brakes, until the hand brakes are released. Air and hand brakes should never be used at the same time on the same car.

If while running, the brakes go on suddenly, move the brake handle to "*emergency stop*" position and let it stay there until signal is given to release.

In running a freight train that has the use of air on drivers and tender brakes, if you wish to slow up or stop, do not apply the air until the slack of the train is close against the engine. The same practice should be maintained in handling trains when only part of its cars have air brakes.

FOR A SUDDEN STOP, move the brake handle at once to "*emergency stop*," and leave it there until the train stops.

The valves inside of the brake valve, also the air whistle valve and chamber at the main reservoir, marked "*air signal reducing valve*," should be taken apart and well cleaned frequently.

Engineers should keep the steam cylinder well lubricated, and use but a small quantity of good quality well oil in the air pump cylinder; do not use carbon (or coal) oil in air pump cylinder, as there is danger of exploding the main reservoir. When the pump becomes lazy and wheezy a pint of weak solution of concentrated lye poured into the air pump cylinder while the pump is working, will remove all accumulations of gum from the cylinder, valves and pipes, and gives new life to the pump.

Keep the steam and air piston glands nicely packed. Attend to them often and don't pack too tight. If the packing in the air end of the cylinder gives trou-

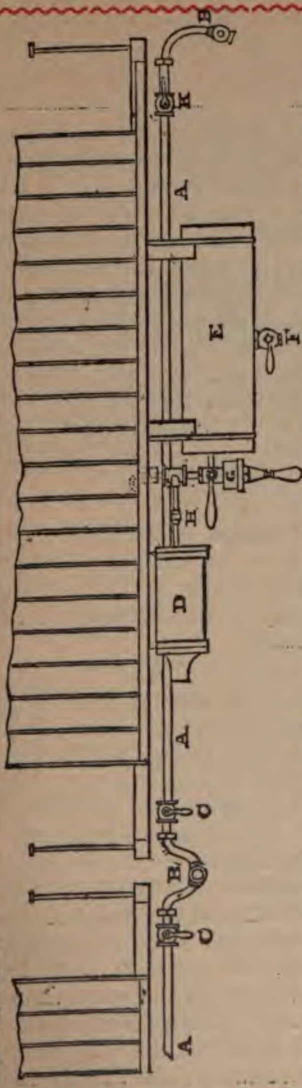
ble by burning out very often, the air valves have too much lift. New valves are needed. The travel of pistons in driver brake cylinders should not exceed 3 or 4 inches. Drain the water out of the main reservoir once a week. The water in the main pipe under the tender should be drained out every day.

BRAKES WILL NOT RELEASE.

If cars having different air pressures be coupled together the brakes will apply themselves on those which have the highest pressure. In this case, or in case that the brake of a car be applied by loss of pressure from the train pipe, open the cock in the head of the brake cylinder D, *or if there is no cock there* then turn the handle of the release cock F in diagram, to a vertical position. When the air has escaped and the brakes are fully released, turn the handle back to a horizontal position. Should the brake rigging of any car become damaged, or should it *repeatedly fail to release promptly*, turn the handle of the four-way cock (H in diagram,) to a position half-way between vertical and horizontal, and open the release cock F and leave them so; the quick acting triple valve has a stop cock instead of a four-way cock, which must be closed; this will discontinue the use of the brake on that car.

AIR BRAKE.

If your train is equipped with the old style triple valve and you wish to use the brake as an air brake and not automatically, turn to a vertical position the handles of *all cocks* in the train except of the train pipe cock (K in diagram,) at the rear end of the last car. You cannot use straight air with the new style triple valve.



EXPLANATION OF DIAGRAM.—A A Train Pipe; B B Hose and Couplings; C C K Stop Cocks in Train Pipe; D Brake Cylinder; E Auxiliary Reservoir; F Release Cock. The best place to put the Release Cock F is in the Cylinder D, because the brakes can be released quicker from the cylinder than from the reservoir; many cars have cocks in both cylinder and reservoir, G, Triple Valve; H Four-way Cock.

TO MAKE UP A TRAIN.

After the engine is attached to the train, see that all the hand brakes are off, then connect all couplings and turn to a vertical position the handles (*pointing down*) of all train pipe cocks (C C in diagram,) except that (K in diagram) at the rear end of last car,—the handle of this cock must be horizontal. The handle of the cock connected with the triple valve should be horizontal and the release cock F (whether it be in the auxiliary reservoir or cylinder head D, or in both places) should be closed. The brakes should then be tested under every car. This test should not be made until a pressure of at least forty pounds in the auxiliary reservoirs has been attained. In making the test the engineer should lock the air in the train pipe by

placing the handle of the three-way cock in a fore and aft position and then notice by the air gauge that the same pressure is retained in the pipe. During this test the inspector or train hand should ascertain from the engineer whether there is any indication of leakage. If there are no leaks the engineer will apply the brakes and release them, noting the result. Then apply the brakes, after which the person who assists in the test should pass along the whole train and see that every brake is well applied. The brakes should then be released, when they should be again examined to see that every brake is free. *These tests should be made every time cars are attached to a train.*

TO CUT OFF CARS.

First see that all the brakes in the train are fully released, then turn to a horizontal position the handles of the train pipe cocks (C C in diagram,) each side of the couplings to be separated, then disconnect the hose by hand.

SPECIAL TO CAR INSPECTORS.

The brake gear under cars should be so adjusted that when the brakes are fully applied that the travel of the pistons in the brake cylinders will not exceed 8 or 9 inches. The pipes and joints must be kept tight. The valve for the application of brakes from inside the cars should be examined regularly and kept air tight, and when leaks are discovered they should be corrected, if serious, before the car is again used. The triple valves should be oiled and cleaned once a month; they should also be kept clear of water by slacking the bottom nut one half turn; let the water escape and screw it up again—this should be lone often. The brake cylinder should be kept eaned and oiled every three months. In taking up e slack in brake connections, push the levers back

to their proper places and take up the slack by the under-connections or dead levers.

THE BRAKES MAY BE APPLIED.

The *brakes may be applied from the train* in either of three ways:

First—By raising the lever of the valve in the saloon and keeping it raised until the train is stopped.

Second—By uncoupling the hose between any two cars.

Third—By turning to a vertical position the handle of the train pipe (K in the diagram) on rear of last car in the train.

Never use these means except in cases of emergency.

SUPPLEMENT TO THE REASON WHY.

On page 28 of "the Reason Why," is a statement that, "*When the steam has done its work in that end of the cylinder you want to get rid of it as soon as possible.*" We wish to get rid of it because we want to get steam into the other end of the cylinder and do not want pressure on both sides of the piston at the same time. If the pressure could all be let out of one end of the cylinder as soon as steam enters at the other end, and if there was a free passage for the exhaust after the steam is discharged from the cylinder, there would be no back pressure to overcome; but then we need some steam in that end of the cylinder for a cushion for the piston while passing the centre. The best constructed valve motion gives the smallest amount of back pressure, allowing just enough compressed steam to form a cushion and to give the full boiler pressure against the piston as soon as the valve opens.

OMISSION.

In the index to "Reason Why"—*Tumbling Shaft broken, page 17.* The words "Tumbling Shaft" should have been placed with the same heading with and before the words "Saddle Pin."

APPENDIX.

RULES FOR THE COURSE TO BE FOLLOWED BY THE BYSTANDERS IN CASE OF INJURY WHEN SURGICAL ASSISTANCE CANNOT BE AT ONCE OBTAINED.

The dangers to be feared in these cases are: *Shock or collapse, loss of blood, and unnecessary suffering in the moving of the patient.*

I. In SHOCK the injured person lies pale, faint, cold, sometimes insensible, with labored pulse and breathing.

Apply external warmth, by wrapping him up (not merely covering him over) in blankets, quilts, or extra clothes. Bottles of hot water, or hot bricks (not too hot) may also be wrapped up in cloths and put to the arm-pits along the sides and between the feet if they are uninjured.

If the patient has NOT been drinking, give brandy or whiskey in *table-spoonful* doses every 15 or 20 minutes—less frequently as he gets better. Food (strong soup is the best) should also be given now and then.

II. In small, clean cut wounds, bring the edges together with strips of adhesive plaster; in wounds more than an inch in length, unite the edges with stitches.

If a wound is ragged and torn, clean it as thoroughly as possible; then cover it with vaseline and a thick layer of cotton. Fix this dressing by applying a bandage as even as possible, and with moderate firmness.

When a limb is evidently broken, place it in as natural a position as possible, until the local surgeon of the company can see the patient.

III. LOSS OF BLOOD.—If the patient is NOT bleeding, *do not* apply any constriction to the limb, but cover the wounded part lightly with the softest rags to be had (linen is the best.)

If there is bleeding, check it by pressure with a sponge moistened with cold or very hot water; do not try to stop it by binding up the wound. *The current of the blood to the part must be checked.* To do this, find the artery, by its beating; lay a firm and even compress or pad (made of cloth or rags rolled up, or a round stone or piece of wood well wrapped) OVER THE ARTERY; tie a handkerchief around the limb and compress; put a bit of stick through the handkerchief and twist the latter up until it is *just tight enough to stop the bleeding*;

then put one end of the stick under the handkerchief to prevent untwisting.

The artery in the thigh runs along the inner side of the muscle in front near the bone. A little above the knee, it passes to the back of the bone. In injuries at or above the knee, apply the compress high up, on the inner side of the thigh, with the knot on the outer side of the thigh. When the leg is injured below the knee, apply the compress at the back of the thigh just above the knee and the knot in front.

The artery in the arm runs down the inner side of the large muscle in front, quite close to the bone; low down it gets further forward toward the bend of the elbow. It is most easily found and compressed a little above the middle.

Care should be taken to examine the limb from time to time, and to lessen the compression if it becomes very cold or purple: tighten up the handkerchief again if the bleeding begins afresh.

IV. To Transport a Wounded Person Comfortably.—Make a soft and even bed for the injured part, of straw, folded blankets, quilts, or pillows laid on a board, with side-pieces of board nailed on, where this can be done. If possible let the patient be laid on a door, shutter, settee, or some firm support, properly covered. Have sufficient force to lift him steadily, and let those who bear him NOT keep step.

V. Should any important arteries be opened, apply the handkerchief as recommended. Secure the vessel by a surgeon's dressing forceps, or by a hook, then have a silk ligature put around the vessel and tighten tight.

VI. Should the bleeding be from arterial vessels of small size, apply the PERSULPHATE OF IRON, either in tincture or in powder, by wetting a piece of lint or sponge with the solution, then, after bleeding ceases, apply a compress against the parts to sustain them during the application of the persulphate of iron, and to prevent further bleeding should it occur. The persulphate of iron should be kept on hand in all workshops

Send for a Physician in all cases.

FOR BURNS OR SCALDS.

In the early stage, soon after the accident, if there is no separation of the skin, do not cut the bladder, but allow the *bladder* of *water*, of whatever size, to remain untouched; merely dress it with a piece of linen or muslin, lightly coated with simple cerate.

If the parts are denuded of the skin, dress the part with *cotton, the object* being to exclude the air and prevent sup-

puration. If cotton cannot be procured, apply any covering until you can have an ointment made of beeswax and sweet oil, equal parts, or lime water and linseed oil; or lay on scraped potatoes or carrots, or sprinkle flour on the injured surface when the above cannot be procured. Flour is troublesome in its removal.

If the scald is extensive and on the body, COLD APPLICATIONS are NOT PROPER; then use warm fomentations, or, in the case of a child, the WARM BATH. Keep the air from the wound as much as possible; do not remove the dressing often. When a cold lotion is used, pour it upon the rags, letting them remain undisturbed. A little baking soda placed upon a burn will allay the pain.

BRUISES.

Use tepid applications at first. After inflammation has subsided, use stimulating applications, as vinegar and water, alcohol, camphorated liniment.

SPRAINS.

Elevate the limb; keep the joint perfectly quiet; apply lukewarm lotions or fomentations. When inflammation has ceased, apply stimulating liniments and bandages; shower the part with cold water, alternating with warm water.

TO RESTORE PERSONS AFFECTED BY COLD.

FOR FROST-BITE OR NUMBNESS.—Restore warmth *gradually*, in proportion as circulation in the parts or body increases.

FOR A FROZEN LIMB.—Rub with snow, and place in cold water for a short time. When sensation returns, place again in cold water; add heat *very gradually*, by adding warm water.

IF APPARENTLY DEAD OR INSENSIBLE.—Strip entirely of clothes, and cover body, with exception of mouth and nostrils, with SNOW or ICE COLD WATER. When body is thawed, dry it; place it in a cold bed; rub with warm hands under the cover; continue this for hours. If life appears, give small injections of camphor and water; put a drop of spirits of camphor on tongue; then rub body with spirits and water, finally with spirits; then give tea, coffee, or brandy and water.

Send for a physician in all cases.

APPARENT DEATH FROM BREATHING NOXIOUS VAPOR, AS IN WELLS, &c.

If insensible, expose person in the open air; sprinkle cold water on face and head; rub strong vinegar about nostrils; give drink of vinegar and water. If suffocated by breathing

fumes of charcoal, proceed as above, and excite breathing as in remedy given in cases of drowning.

Send for a physician in all cases.

To purify wells, &c., shower water down them until a candle will burn at the bottom with a clear flame.

RULES FOR ACCIDENTS ON WATER.

When upset in a boat, or thrown into the water and unable to swim, draw the breath in well; keep the mouth tight shut; do not struggle and throw the arms up, but yield quietly to the water; hold the head well up, and stretch out the hands only *below* the water; to throw the hands or feet *up*, will pitch the head *down*, and cause the whole person to go immediately under water. Keep the head *above*, and everything else under water.

METHOD TO BE USED IN CASES OF DROWNING.

DR. MARSHALL HALL'S REMEDY.

Send for a physician in all cases.

1st. Treat the patient INSTANTLY ON THE SPOT in the OPEN AIR, freely exposing the face, neck, and chest to the breeze, except in severe weather.

2d. In order to CLEAR THE THROAT, place the patient gently on the face, with one wrist under the forehead, that all fluid, and the tongue itself, may fall forward, and leave the entrance into the windpipe free.

3d. To EXCITE RESPIRATION, turn the patient slightly on his side, and apply some irritating or stimulating agent to the nostrils, as VERATRINE, DILUTE AMMONIA, etc.,—as snuff, or apply a feather to the throat.

4th. Make the face warm by brisk friction; then dash cold water upon it.

5th. If not successful, lose no time; but, TO IMITATE RESPIRATION, place the patient on his face, and turn the body gently, but completely ON THE SIDE, A LITTLE BEYOND; then again on the face, and so on alternately. . Repeat these movements deliberately and persistently FIFTEEN TIMES ONLY in a minute. (When the patient lies on the breast, this cavity is COMPRESSED by the weight of the body, *ex*piration takes place. When he is turned on the side this pressure is removed and *in*spiration occurs.)

6th. When the prone position is resumed, make a uniform and efficient pressure ALONG THE SPINE, removing the pres-

sure immediately, before rotation on the side. (The pressure augments the *ex*piration; the rotation commences *in*spiration.) Continue these measures.

7th. Rub the limbs UPWARD with FIRM PRESSURE, and with ENERGY. (The object being to aid the return of venous blood to the heart.)

8th. Substitute for the patient's wet clothing, if possible, such other covering as can be instantly procured, each bystander supplying a coat or cloak, &c. Meantime, and from time to time, TO EXCITE INSPIRATION, let the surface of the body be SLAPPED briskly with the hand.

9th. Rub the body briskly till it is dry and warm, then dash COLD water upon it, and repeat the rubbing.

AVOID the immediate removal of the patient, as it involves a DANGEROUS LOSS OF TIME; also, the use of bellows, or any FORCING instruments; also, the WARM BATH, and ALL ROUGH TREATMENT.

SUN-STROKE.

Take the patient immediately into the shade; place in a half recumbent position—head raised; loosen the clothes about the neck and chest; apply immediately, ice or cold wet cloths to the head and nape of the neck, changing them frequently.

Send for a physician as soon as possible.

PROTECT YOURSELF FROM APPROACHING TRAINS

TIME AND SPEED TABLES.

					Minutes. Seconds. 10th of a Second.			
10	miles	per	hour	is	6.00	to	1	mile.
11	"	"	"	"	5.27	"	1	"
12	"	"	"	"	5.00	"	1	"
13	"	"	"	"	4.37	"	1	"
14	"	"	"	"	4.17	"	1	"
15	"	"	"	"	4.00	"	1	"
16	"	"	"	"	3.45	"	1	"
17	"	"	"	"	3.32	"	1	"
18	"	"	"	"	3.20	"	1	"
19	"	"	"	"	3.09.5	"	1	"
20	"	"	"	"	3.00	"	1	"
21	"	"	"	"	2.51.5	"	1	"
22	"	"	"	"	2.43.5	"	1	"
23	"	"	"	"	2.36.5	"	1	"
24	"	"	"	"	2.30	"	1	"
25	"	"	"	"	2.24	"	1	"
26	"	"	"	"	2.18.6	"	1	"
27	"	"	"	"	2.13.3	"	1	"
28	"	"	"	"	2.08.5	"	1	"
29	"	"	"	"	2.04	"	1	"
30	"	"	"	"	2.00	"	1	"
31	"	"	"	"	1.56	"	1	"
32	"	"	"	"	1.52.5	"	1	"
33	"	"	"	"	1.49	"	1	"
34	"	"	"	"	1.45.6	"	1	"
35	"	"	"	"	1.42.6	"	1	"
36	"	"	"	"	1.40	"	1	"
37	"	"	"	"	1.37.3	"	1	"
38	"	"	"	"	1.34.7	"	1	"
39	"	"	"	"	1.32.3	"	1	"
40	"	"	"	"	1.30	"	1	"
41	"	"	"	"	1.27.7	"	1	"
42	"	"	"	"	1.25.7	"	1	"
43	"	"	"	"	1.23.5	"	1	"
44	"	"	"	"	1.21.7	"	1	"
45	"	"	"	"	1.20.0	"	1	"
46	"	"	"	"	1.18.2	"	1	"
47	"	"	"	"	1.16.6	"	1	"

PROTECT YOURSELF FROM APPROACHING TRAINS.

TIME AND SPEED TABLES.

					Minutes. Seconds. 10th of a Second.			
48	miles	per	hour	is	1.15	to	1	mile.
49	"	"	"	"	1.13.5	"	1	"
50	"	"	"	"	1.12	"	1	"
51	"	"	"	"	1.10.6	"	1	"
52	"	"	"	"	1.09.4	"	1	"
53	"	"	"	"	1.07.9	"	1	"
54	"	"	"	"	1.06.6	"	1	"
55	"	"	"	"	1.05.4	"	1	"
56	"	"	"	"	1.04.3	"	1	"
57	"	"	"	"	1.03.2	"	1	"
58	"	"	"	"	1.02.2	"	1	"
60	"	"	"	"	1.00	"	1	"
65	"	"	"	"	0.55.3	"	1	"
70	"	"	"	"	0.51.4	"	1	"
75	"	"	"	"	0.48	"	1	"
80	"	"	"	"	0.45	"	1	"
85	"	"	"	"	0.42.3	"	1	"
90	"	"	"	"	0.40	"	1	"
95	"	"	"	"	0.37.9	"	1	"
100	"	"	"	"	0.36	"	1	"

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNNING TENTHS OF A MILE.

Speed per Hour in Miles.	1 Tenth.	2 Tenths.	3 Tenths.	4 Tenths.	5 Tenths.	6 Tenths.	7 Tenths.	8 Tenths.	9 Tenths.
	Seconds 10th of a Second.	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*	*Minutes Seconds*
10	36.0	1.12	1.48	2.24	3.00	3.36	4.12	4.48	5.24
11	32.7	1.05	1.38	2.10	2.43	3.16	3.48	4.21	4.54
12	30.0	1.00	1.30	2.00	2.30	3.00	3.30	4.00	4.30
13	27.7	0.55	1.23	1.50	2.18	2.46	3.13	3.41	4.09
14	25.7	0.51	1.17	1.42	2.08	2.34	2.59	3.25	3.51
15	24.0	0.48	1.12	1.36	2.00	2.24	2.48	3.12	3.36
16	22.5	0.45	1.07	1.30	1.52	2.15	2.37	3.00	3.22
17	21.2	0.42	1.03	1.24	1.46	2.07	2.28	2.49	3.10
18	20.0	0.40	1.00	1.20	1.40	2.00	2.20	2.40	3.00
19	18.9	0.37	0.56	1.15	1.34	1.53	2.12	2.31	2.50
20	18.0	0.36	0.54	1.12	1.30	1.48	2.06	2.24	2.42
24	15.0	0.30	0.45	1.00	1.15	1.30	1.45	2.00	2.15
25	14.4	0.28	0.43	0.57	1.12	1.26	1.40	1.55	2.09
30	12.0	0.24	0.36	0.48	1.00	1.12	1.24	1.36	1.48
35	10.2	0.20	0.30	0.40	0.51	1.01	1.11	1.21	1.31
40	09.0	0.18	0.27	0.36	0.45	0.54	1.03	1.12	1.21
45	08.0	0.16	0.24	0.32	0.40	0.48	0.56	1.04	1.12
48	07.5	0.15	0.22	0.30	0.37	0.45	0.52	1.00	1.07
50	07.2	0.14	0.21	0.28	0.36	0.43	0.50	0.57	1.04
55	06.5	0.13	0.19	0.26	0.32	0.39	0.45	0.52	0.58
60	06.0	0.12	0.18	0.24	0.30	0.36	0.42	0.48	0.54
65	05.5	0.11	0.16	0.22	0.27	0.33	0.38	0.44	0.49

Fractions of a second are included in these tables only where they amount to a full second, in all except the first column of the tenth of a mile table.

In using these tables, see in the column to your left hand the speed you wish to run on the miles table, then follow that line until it meets the number of miles or tenths it is to the place you wish to go, where you will find the amount of time it takes to run it. For example: if you wish to run 17 miles an hour to a place that is 12 miles and 6 tenths distant, opposite 17 and under 12 you will find 42 minutes and 24 seconds, then opposite 17 and under 6 on the first, or tenths, table you will find 2 minutes and 7 seconds, which being added to the 42-24, makes 44 minutes and 31 seconds.

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNNING.

Speed per hour in Miles.	1 MILE. Hours Minutes Seconds	2 MILES. Hours Minutes Seconds	3 MILES. Hours Minutes Seconds	4 MILES. Hours Minutes Seconds	5 MILES. Hours Minutes Seconds	6 MILES. Hours Minutes Seconds	7 MILES Hours Minutes Seconds
10	0.06.00	0.12.00	0.18.00	0.24.00	0.30.00	0.36.00	0.42.00
11	0.05.27	0.10.54	0.16.21	0.21.48	0.27.15	0.32 42	0.38.09
12	0.05.00	0.10.00	0.15.00	0.20.00	0.25.00	0.30.00	0.35.00
13	0.04.37	0.09.14	0.13.51	0.18.28	0.23.05	0.27.42	0.32.19
14	0.04.17	0.08.34	0.12.51	0.17.08	0.21.25	0.25.42	0.29.59
15	0.04.00	0.08.00	0.12.00	0.16.00	0.20.00	0.24.00	0.28.00
16	0.03.45	0.07.30	0.11.15	0.15.00	0.18.45	0.22.30	0.26.15
17	0.03.32	0.07.04	0.10.36	0.14.08	0.17.40	0.21.12	0.24.44
18	0.03.20	0.06.40	0.10.00	0.13.20	0.16.40	0.20.00	0.23.20
19	0.03.09	0.06.19	0.09.28	0.12.38	0.15.47	0.18.57	0.22.06
20	0.03.00	0.06.00	0.09.00	0.12.00	0.15.00	0.18.00	0.21.00
24	0.02.30	0.05.00	0.07.30	0.10.00	0.12.30	0.15.00	0.17.30
25	0.02.24	0.04.48	0.07.12	0.09.36	0.12 00	0.14.24	0.16.48
30	0.02.00	0.04.00	0.06.00	0.08.00	0.10.00	0.12.00	0.14.00
35	0.01.42	0.03.25	0.05.07	0.06.50	0.08.33	0.10.15	0.11.58
40	0.01.30	0.03.00	0.04.30	0.06.00	0.07.30	0.09.00	0.10.30
45	0.01.20	0.02.40	0.04.00	0.05.20	0.06.40	0.08.00	0.09.20
48	0.01.15	0.02.30	0.03.45	0.05.00	0.06.15	0.07.30	0.08.45
50	0.01.12	0.02.24	0.03.36	0.04.48	0.06.00	0.07.12	0.08.24
55	0.01.05	0.02.11	0.03.16	0.04.22	0.05.27	0.06.33	0.07.38
60	0.01.00	0.02.00	0.03.00	0.04.00	0.05.00	0.06.00	0.07.00
65	0.00.55	0.01.50	0.02.46	0.03.41	0.04.36	0.05.32	0.06.27

In using these tables, see in the left column the speed you wish to run, then follow that line until it meets the number of miles it is to the place you wish to go, where you will find the amount of time it takes to run it. For example: you wish to run 17 miles an hour to a place that is 12 miles off; opposite 17 and under 12 you find that you have 42 minutes and 24 seconds to run the 12 miles at a 17 mile speed.

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNNING.

Speed per hour in Miles.	8 Miles. *Hours Minutes Seconds*	9 Miles. *Hours Minutes Seconds*	10 Miles. *Hours Minutes Seconds*	11 Miles. *Hours Minutes Seconds*	12 Miles. *Hours Minutes Seconds*	13 Miles. *Hours Minutes Seconds*	14 Miles. *Hours Minutes Seconds*
10	0.48.00	0.54.00	1.00.00	1.06.00	1.12.00	1.18.00	1.24.00
11	0.43.36	0.49.03	0.54.30	1.00.00	1.05.24	1.10.51	1.16.18
12	0.40.00	0.45.00	0.50.00	0.55.00	1.00.00	1.05.00	1.10.00
13	0.36.56	0.41.33	0.46.10	0.50.47	0.55.24	1.00.00	1.04.38
14	0.34.16	0.38.33	0.42.50	0.47.07	0.51.24	0.55.41	1.00.00
15	0.32.00	0.36.00	0.40.00	0.44.00	0.48.00	0.52.00	0.56.00
16	0.30.00	0.33.45	0.37.30	0.41.15	0.45.00	0.48.45	0.52.30
17	0.28.16	0.31.48	0.35.20	0.38.52	0.42.24	0.45.56	0.49.28
18	0.26.40	0.30.00	0.33.20	0.36.40	0.40.00	0.43.20	0.46.40
19	0.25.16	0.28.25	0.31.35	0.34.44	0.37.54	0.41.03	0.44.13
20	0.24.00	0.27.00	0.30.00	0.33.00	0.36.00	0.39.00	0.42.00
24	0.20.00	0.22.30	0.25.00	0.27.30	0.30.00	0.32.30	0.35.00
25	0.19.12	0.21.36	0.24.00	0.26.24	0.28.48	0.31.12	0.33.36
30	0.16.00	0.18.00	0.20.00	0.22.00	0.24.00	0.26.00	0.28.00
35	0.13.41	0.15.23	0.17.06	0.18.48	0.20.31	0.22.14	0.23.56
40	0.12.00	0.13.30	0.15.00	0.16.30	0.18.00	0.19.30	0.21.00
45	0.10.40	0.12.00	0.13.20	0.14 40	0.16.00	0.17.20	0.18.40
48	0.10.00	0.11.15	0.12.30	0.13.45	0.15.00	0.16.15	0.17.30
50	0.09.36	0.10.48	0.12.00	0.13.12	0.14.24	0.15.36	0.16.48
55	0.08.44	0.09.49	0.10.55	0.12.00	0.13.06	0.14.11	0.15.17
60	0.08.00	0.09.00	0.10.00	0.11.00	0.12.00	0.13.00	0.14.00
65	0.07.22	0.08.18	0.09.13	0.10.08	0.11.04	0.11.59	0.12.54

In using these tables, see in the left column the speed you wish to run, then follow that line until it meets the number of miles it is to the place you wish to go, where you will find the amount of time it takes to run it. For example: you wish to run 17 miles an hour to a place that is 12 miles off; *opposite 17 and* under 12 you will find that you have 42 min*utes and 24 seconds* to run the 12 miles at a 17 mile speed.

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNNING.

Speed per hour in Miles.	15 MILES. *Hours Minutes Seconds*	16 MILES. *Hours Minutes Seconds*	17 MILES. *Hours Minutes Seconds*	18 MILES. *Hours Minutes Seconds*	19 MILES. *Hours Minutes Seconds*	20 MILES. *Hours Minutes Seconds*
10	1.30.00	1.36.00	1.42.00	1.48.00	1.54.00	2 00.00
11	1.21.45	1.27.12	1.32.39	1.38.06	1.43.33	1.49.00
12	1.15.00	1.20.00	1.25.00	1.30.00	1.35.00	1.40.00
13	1.09.15	1.13.52	1.18.29	1.23.06	1.27.43	1.32.20
14	1.04.15	1.08.32	1.12.49	1.17.06	1.21.23	1.25.40
15	1.00.00	1.04.00	1.08.00	1.12.00	1.16.00	1.20.00
16	0.56.15	1.00.00	1.03.45	1.07.30	1.11.15	1.15.00
17	0.53.00	0.56.32	1.00 00	1.03.36	1.07.08	1.10.40
18	0.50.00	0.53.20	0.56.40	1.00 00	1.03.20	1.06 40
19	0.47.22	0.50 32	0.53.41	0.56.51	1.00.00	1.03.10
20	0.45.00	0.48.00	0.51.00	0.54.00	0 57.00	1.00 00
24	0.37.30	0.40 00	0.42.30	0.45.00	0.47.30	0.50.00
25	0.36.00	0. 8.24	0.40.48	0.43.12	0.45.36	0.48.00
30	0.30.00	0.32.00	0.34.00	0.36.00	0.38.00	0.40.00
35	0.25.39	0.27.22	0.29.04	0.30.47	0.32.29	0.34.12
40	0.22.30	0.24.00	0.25.30	0.27.00	0.28.30	0.30.00
45	0.20.00	0.21.20	0.22.40	0.24.00	0.25.20	0.26.40
48	0.18.45	0.20.00	0.21.15	0.22.30	0.23 45	0 25.00
50	0.18.00	0.19.12	0.20.24	0 21.36	0.22.48	0.24.00
55	0.16.22	0.17.28	0.18.33	0.19.39	0.20.44	0.21.50
60	0.15.00	0.16.00	0.17.00	0.18.00	0.19 00	0.20.00
65	0.13.50	0.14.45	0.15.40	0.16.36	0 17.31	0.18 26

In using these tables see in the left column the speed you wish to run, then follow that line until it meets the number of miles it is to the place you wish to go, where you will find the amount of time it takes to run to it. For example: you wish to run 17 miles an hour to a place that is 12 miles off; opposite 17 and under 12 you find that you have 42 minutes and 2 seconds to run the 12 miles at a 17 mile speed.

The usual maximum speed for first-class trains is one and one quarter minutes to the mile which, as is seen under the 1 mile column, is 48 miles per hour. The speed for second and third class trains is usually three and a half minutes to the mile or about 17 miles per hour. The speed for work or gravel trains is usually two and one-half minutes to the mile, or 24 miles per hour.

The usual maximum speed for first-class trains is one and one-quarter minutes to the mile, which, as is seen under the 1 mile column, is 48 miles per hour. The speed for second and third-class trains is usually three and a half minutes to the mile or about 17 miles per hour. The speed for work or gravel trains is usually two and one-half minutes to the mile, or 24 miles per hour.

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNNING.

Speed per hour in Miles.	21 Miles.	22 Miles.	23 Miles.	24 Miles.	25 Miles.	26 Miles.
	Hours Minutes Seconds	Hours Minutes Seconds	Hours Minutes Seconds	Hours Minutes Seconds	Hours Minutes Seconds	Hours Minutes Seconds
10	2.06.00	2.12.00	2.18.00	2.24.00	2.30.00	2.36.00
11	1.54.27	2.00.00	2.05.21	2.10.48	2.16.15	2.21.42
12	1.45.00	1.50.00	1.55.00	2.00.00	2.05.00	2.10.00
13	1.36.57	1.41.34	1.46.11	1.50.48	1.55.25	2.00.00
14	1.29.57	1.34.14	1.38.31	1.42.48	1.47.05	1.51.22
15	1.24.00	1.28.00	1.32.00	1.36.00	1.40.00	1.44.00
16	1.18.45	1.22.30	1.26.15	1.30.00	1.33.45	1.37.30
17	1.14.12	1.17.44	1.21.16	1.24.48	1.28.20	1.31.52
18	1.10.00	1.13.20	1.16.40	1.20.00	1.23.20	1.26.40
19	1.06.19	1.09.29	1.12.38	1.15.47	1.18.56	1.22.06
20	1.03.00	1.06.00	1.09.00	1.12.00	1.15.00	1.18.00
24	0.52.30	0.55.00	0.57.30	1.00.00	1.02.30	1.05.00
25	0.50.24	0.52.48	0.55.12	0.57.36	1.00.00	1.02.24
30	0.42.00	0.44.00	0.46.00	0.48.00	0.50.00	0.52.00
35	0.35.55	0.37.38	0.39.20	0.41.03	0.42.45	0.44.28
40	0.31.30	0.33.00	0.34.30	0.36.00	0.37.30	0.39.00
45	0.28.00	0.29.20	0.30.40	0.32.00	0.33.20	0.34.40
48	0.26.15	0.27.30	0.28.45	0.30.00	0.31.15	0.32.30
50	0.25.12	0.26.24	0.27.36	0.28.48	0.30.00	0.31.12
55	0.22.55	0.24.00	0.25.06	0.26.12	0.27.17	0.28.23
60	0.21.00	0.22.00	0.23.00	0.24.00	0.25.00	0.26.00
65	0.19.22	0.20.17	0.21.12	0.22.08	0.23.03	0.23.58

In using these tables see in the left column the speed you wish to run, then follow that line until it meets the number of miles it is to the place you wish to go, where you will find the amount of time it takes to run it. For example: you wish to run 17 miles an hour to a place that is 12 miles off; opposite *17 and under 12, you find that you have 42 minutes and 24 seconds to run the 12 miles* at a 17 mile speed.

TABLE

Showing the amount of time used in running from one Station to another, at different Speeds.

TIME FOR RUNN NG.

Speed per hour in Miles.	27 Miles. Hours Minutes Seconds	28 Miles. Hours Minutes Seconds	29 Miles. Hours Minutes Seconds	30 Miles. Hours Minutes Seconds
10	2.42.00	2.48.00	2.54.00	3.00.00
11	2.27.09	2.32.36	2.38.03	2.43.30
12	2.15.00	2.20.00	2.25.00	2.30.00
13	2.04.39	2.09.16	2.13.53	2.18.30
14	1.55.39	2.00.00	2.04.13	2.08.30
15	1.48.00	1.52.00	1.56.00	2.00.00
16	1.41.15	1.45.00	1.48.45	1.52.30
17	1.35.24	1.38.56	1.42.28	1.46.00
18	1.30.00	1.33.20	1.36.40	1.40.00
19	1.25.15	1.28.25	1.31.34	1.34.45
20	1.21.00	1.24.00	1.27.00	1.30.00
24	1.07.30	1.10.00	1.12.30	1.15.00
25	1.04.48	1.07.12	1.09.36	1.12.00
30	0.54.00	0.56.00	0.58.00	1.00.00
35	0.46 11	0.47.53	0.49.36	0.51.19
40	0.40.30	0.42.00	0.43.30	0.45.00
45	0.36.00	0.37.20	0.38.40	0.40.00
48	0.33.45	0.35.00	0.36.15	0.37.30
50	0.32.24	0.33.36	0.34.48	0.36.00
55	0.29.28	0.30.34	0.31.39	0.32.45
60	0.27.00	0.28.00	0.29 00	0.30.00
65	0.24.54	0.25.49	0.26 44	0.27.40

The usual maximum speed for first-class trains is one and one-quarter minutes to the mile, which, as is seen under the 1 mile column, is 48 miles per hour. The speed for second and third-class trains is usually three and a half minutes to the mile or about 17 miles per hour. The speed for work or gravel trains is usually two and one half minutes to the mile, or 24 miles per hour.

Fractions of seconds are included in above tables only when they amount to a full second.

The price of this book sent by mail post-paid is one dollar and fifty cents. Amount can be sent by Money Order, Postal Note, or Registered Letter. Cash must accompany all orders. No books will be sent C. O D.

ADDRESS,

S. A. ALEXANDER,
Lock Box, 258,
YORK, PENN'A.

Yours Truly
S. A. Alexander

KEY

—TO—

READY REFERENCE

—FOR—

Locomotive Engineers

—AND—

FIREMEN,

—BY—

S. A. ALEXANDER,

YORK, PA.

YORK, PENN'A.

1888.

PREFACE.

Having been frequently urged by Engineers and Firemen, and, because I frequently receive letters asking for reasons why certain instructions that are given in my Ready Reference should be followed, I have prepared this work. I feel it a duty to contribute as far as lays in my power all information that I have to my fellow beings, especially to those who are engaged in my own occupation. I have been further prompted to issue this work because of my early experience in learning the locomotive business. It was a common custom in those days if a "cub" asked a "Jour" for information, to get the reply "go find out yourself as I did." Those old chaps usually kept all of their knowledge corked up as secrets, and there are yet some people who are unwilling to become man helpers and "let their light shine."

Some of the items in the "Ready Reference" need no explanation and are not noticed in this work.

Very Truly Yours,

S. A. ALEXANDER.


CHAMPION
20
MOSS ENG. CO. N. Y.

INDEX.

will be apt to become full of ice and burst; it is best to blow steam through them to blow the water out if you can, but in any and all cases take out the frost plugs or slack the joints, to guard against leaky tank or check valves filling the pipes after being drained.

If the weather is very cold and there is any possibility of water freezing in the boiler, the water should be let out of both tank and boiler. It causes a great strain on them if ice becomes solid in them.

BLOCKING CROSS-HEADS.

Cross-heads should be blocked at the back ends of the guides, because if by any means they should break loose from the blocking and steam should get into the cylinder less damage would be done if the piston was forced ahead toward the front cylinder head, than if it was forced to the back head, if it went forward it is probable that only the front cylinder head would be broken, but if backward there is danger that the expensive back cylinder head as well as the piston, guides and guide yoke would be damaged, but in some cases the cross-head must be blocked ahead and steam must be admitted to the back end of the cylinder; in these cases extra care should be taken to secure the valve by clamping the valve stem securely so that the valve cannot move back.

ENGINE OFF TRACK.

The first thing to do after protecting yourself from approaching trains, is to see if the boiler is high enough at either end to leave either the crown sheet or the front ends of the flues unprotected by water, for with a hot fire if these parts are not well covered with water, either of them may become red hot and may burn or even melt the metal in a short time.

Most engines if not off very badly or too far away *from the track,* will help themselves on without the

aid of another engine by using blocking under the wheels. If you have jacks they will aid materially by setting them to push the engine. Engines can usually be put on the track easier by moving them in the direction opposite to that in which they ran off, that is if they get off by running ahead, they should be moved backward to put them on the track.

Do not ask head quarters for help if you can possibly avoid it.

CLAMPING VALVE STEMS.

A heavy strain put on a valve stem in any direction either up, down or sideways, will prevent its moving. The object of covering the ports with the valve is to prevent steam entering the cylinder and thereby moving the piston.

WATER FOAMING IN BOILER.

The cylinder cocks are opened to save the packing and cylinder heads from damage by water being in the cylinder, as water cannot be compressed, as much damage might be done by it as if they had that much iron in them.

The throttle should be closed "gently," because the water is raised in the boiler and you do not know how much of it is solid. By closing the valve suddenly, the water may drop at once and leave the crown-sheet bare and may damage it. If the throttle is closed slowly the water will settle gradually and give you a chance to put more water in the boiler, for this purpose you put pump and injector to work.

The surface cock is opened because the foaming is caused generally by grease and as it floats on the surface of the water it is blown out when the surface cock is opened. For the same reason if grease is found in the tank, you overflow it at the first water station, the grease rises to the surface and runs off.

Lime is put in the tank to counteract the effect of grease that may adhere to its side. Blue stone put back of the hose screen will counteract the effect of a little grease in the boiler.

Soap put in a tank is as bad to make water foam in boiler as grease.

PUMP FAILS.

But little more can be said about failures of pumps than has already been told in Ready Reference. If the remedies given do not cause them to work, it is not probable that you will have tools with you or time to do necessary repairs such as changing lift of and facing and grinding valves.

PUMPS AND INJECTOR FAIL.

The fire is covered dead to prevent the steam from generating and thereby wasting what water is in the boiler. The engine is stopped for the same purpose and if the water is already too low for you to have time to examine the pumps or injectors the fire must be drawn or the crown sheet and flues will be damaged.

Injectors work partly by vacuum and partly on the principle that bodies in motion give more force than bodies at rest. To illustrate this fact lay a pound weight on your toes, you can probably stand it without much inconvenience; raise the weight three or four feet and let it fall on the same toes, and you will be sure to discover that bodies in motion have the most force.

Steam confined in a boiler may be considered a body at rest; the instant it is released from the boiler it becomes a body in motion, and thus in passing through the pipes and injector it sends water into the boiler at a force much greater than that at which it left the same boiler only an instant before.

THE REASON WHY.

The vacuum in an injector is formed by a small amount of steam being admitted to the injector; at first it passes out of the overflow cock, but the rapid motion of the steam causes a draught in the feed pipe drawing the air out of it. This operation is known as an induced current. To illustrate how this draught is created in the feed pipe, put a little dust (tobacco crumbs will do,) into the hole of a common key, then let the key rest against your chin with its end just up to your lips; then blow over the hole and all of the dust will be drawn out. The motion of the current of air over the hole forms a current that creates a draught. A swift running train will draw the hat off your head, if you stand close enough to it. These are induced currents, and as air cannot exist in any confined place where steam is, the air is driven out of the injector and steam coming in contact with cold water from the feed pipe creates what is known as a vacuum in the injector, water then flows freely into this vacuum, and would be raised as much as twenty feet if desired.

Now if there was a leak in the feed pipe or at any point between the tank and injector, air would be admitted and there would be no vacuum, the water would not raise, consequently the injector would not work. After the vacuum is formed in the injector water flows freely from the overflow cock, more steam is then applied and as steam at 60 pounds pressure travels at the rate of about a half mile in a second, the water being in front of this enormous force, is sent rapidly into the boiler; the steam and water having combined and formed a mixture before leaving the injector forms a body the weight of which opens the check valve and the water goes into the boiler quite warm. The pressure of steam without the weight of the water would not open the check valve. If too much steam is admitted a hole would be made in the water and the

check valve would remain closed, air would be drawn in at the overflow until the pressure of steam overcome it, then steam and water would be discharged from the overflow, if too little steam is admitted, water would come from the overflow, but the check valve would not open. If the injector was hot from leaky throttle or check valve, no vacuum could be formed in it, because it takes cold water to make the vacuum and without the vacuum the injector will not work. The hot water can be let out by slacking the hose nut. If the check valve leaks open the cock in the branch pipe, or if there is no cock slack one of the branch pipe joints to let the hot water out, close the cock and tighten the joint when the injector goes to work. Sometimes a hot injector can be cooled by pouring cold water on it and its check valve—cooling the injector condenses the steam and aids in forming the vacuum.

The opening in the steam nozzle of an injector is very small and sometimes becomes choked and must be cleaned out before the injector will work. A bent steam ram or a badly worn discharge valve will interfere with the proper working of an injector, or anything else that directs the steam away from the centre of the stream of water will cause the injector to work badly Sometimes injectors will work well while the engine is running at ordinary speed and will fly off while running fast; this is caused by the swaying of the tender, especially in curves. The water in the tank inclines to rush toward the rear and breaks the stream of water while passing through the hose, by putting a washer between the hose nut and feed pipe with a hole much smaller than the pipe, water will be held in the pipe while the tank is swaying until the body of water in the tank returns to its natural condition, and the stream of water will not be *broken.* Sometimes a contrary Seller's injector can be

put to work by pulling the lever all the way back; leave it open for a second or just long enough for steam to reach the tank, then close it; in nine cases out of ten you can then make it lift the water and put it to work without further ceremony, even if the check valve does leak a little.

BURST FLUE.

If you can get at the flue from the fire door, you can plug it without drawing the fire by getting a stick of wood long enough to reach the flue and drive the stick into the flue; the stick will burn off nearly up to the flue sheet, but will not burn inside of it. The stick should go into the flue not less than six inches. Or you can cover the fire dead, put the blower on a little, just enough to carry off the smoke from the fire box, then lay a board on top of the coal and crawl in, and if you have tools, caulk the flue, or plug it. Of course you cannot do this if there is an arch in the fire box.

THROTTLE VALVE DISABLED.

As soon as you find that you cannot close the throttle or prevent steam from entering the cylinders, if you have a high pressure of steam, the engine will be apt to slip its drivers. In this case do not use sand, but control the engine with the reverse lever until the pressure is reduced until the engine will not slip If much sand is used there is danger of damaging the machinery.

BROKEN STEAM CHEST.

If the engine receives its steam through ports leading from the top of the cylinder, and the steam pipe is not connected to the steam chest. If the chest is broken and enough of the steam chest studs can be used you can block the steam passages and clamp the blocks with rail splices, after removing the valve rod, valve and main rod. If you cannot make the ports

tight, you can leave the train and run to nearest telegraph office and report to headquarters condition of engine.

ECCENTRIC ROD OR STRAP BROKEN.

If the back motion eccentric rod or strap is broken, both eccentric rods and straps on that side must be taken off; but if only the forward motion is disabled the back motion rod and strap may be left on, providing there is no danger of the eccentric becoming hot and not much running backward required, but in all cases when the back motion is allowed to remain take the link lifter off, or you will have trouble if you wish to reverse, the link will be apt to turn over.

BROKEN VALVE YOKE OR VALVES DISABLED.

The engine is moved until the cross head has moved half way along the guides, because the engine is then at its half stroke, then by moving the reverse lever the valve will move its extreme travel both ways unless the yoke is broken, in which case steam will come from the back cylinder cock only after steam is admitted, the valve stem would push the valve ahead, but if the yoke was broken there would be nothing to draw the valve back, consequently the steam will not enter the front end of the cylinder. If valve stem is broken inside the steam chest it must be taken out and the stuffing box plugged, because pressure of steam would blow the stem out—you could not clamp it.

VALVE BROKEN.

Valves may sometimes not be broken so bad that they need be taken out of the chest. If they can be blocked so as not to allow steam to pass into the cylinder at either end you can leave the valve in the chest, *but must* disconnect and clamp the valve rod.

SADDLE PIN, LIFTER OR LIFTING ARM BROKEN.

If you have not far to go and no reversing to do if either of these pieces are broken. you can run along carefully to the shop without taking any thing down or blocking the links up; you can do the same if you have a broken tumbling shaft or reach rod.

BOTTOM ROCKER-ARM BROKEN.

It will not be necessary to take the link off if it would clear everything within its reach; in fact, if the link and its bearings are not much worn and you have not far to go. the eccentric rods and straps might remain on, only the main rod must be removed, the ports covered and the valve stem clamped.

TO FIND AN ENGINE CENTRE.

The usual shop practice in finding an engine centre, say the front centre, is to move the engine ahead until the cross head is within about one-eighth of an inch of the end of its travel at the front end. Mark on the guide where the cross head stops, open a pair of dividers, say ten or twelve inches and from some point on the main driving wheel cover, scribe a line on the inner edge of the main tire, then move the engine over the centre until the cross head returns to the mark you made on the guide, then from the point you took on the wheel cover with exactly the same distance that you first made the line on the tire, scribe another line on the inner edge of the tire, then divide the space between these lines, then with the dividers set as before with one point of the dividers resting on the same point on the wheel cover, move the engine until the other point of the dividers comes to the middle line on the tire, the engine is then on its dead front centre. Repeat this operation to find the back centre.

DIVIDING VALVES.

Valves should be divided at the points where the steam is cut off from the cylinder, and not at the points where the cylinder receives it. It is the quantity of steam that is used in the cylinder that makes the regular sound of the exhaust and not the time that it enters the cylinder. You cannot get a valve to beat square unless you divide it at the points at which it cuts the steam off so as to make the valve close at equal distances from each end of the travel of the piston in the cylinder, and the reason is that the valve travels faster at those points than at any other points. This matter is more fully explained in my diagram of valve motion accompanying the Ready Reference.

SLIPPED ECCENTRIC.

A very good way to set a slipped eccentric, if you are in a hurry, is to get the engine on its dead centre, as near as you can by the eye, and if the forward motion is slipped, hook the reverse lever clear back, then clamp the valve stem so that the valve cannot move, then take out the bolt that connects the forward motion eccentric rod to the link, then throw the reverse lever all the way ahead being careful that the valves do not move, then by moving the slipped eccentric until you can put the jaw bolt in, the eccentric will be near enough right to run in; only be careful that the eccentrics are not in the same position on the axle, or you will have both set run backward—one eccentric must point up the other down. A back motion eccentric can be set in the same manner, only the reverse lever must be thrown ahead, then clamp the valve stem, then take the jaw bolt out of the back motion rod and move the back motion eccentric until the bolt will go in without moving the valve or rocker arm. When an *engine is on* its dead centre, the valve should be in ex-

actly the same position when the reverse lever is in the extreme back notch as when in extreme forward notch; so if the valve rod does not move *while the pin is out* and the reverse lever is being moved, the eccentric will be nearly right; after the pin is put in the valve rod will move while the lever is being moved, but in the extreme notches will show that the rod is in exactly the same place.

BROKEN CRANK PIN OR BROKEN PARALLEL ROD OR STRAP.

When from any cause a parallel rod is taken off, the corresponding rod on the opposite side should also be removed, because the crank pins on one side of an engine are kept in position by the crank pins on the other side while the engine is passing its centre, as there is no power exerted on the pins while passing centres, the power is all being used on the opposite side, consequently if a rod was left on, while the opposite rod was off, the driving wheels with the rod on would lag behind the other drivers as the pin approached its centre, on account of having no rod on the other side to bring its wheel along with the others, a great strain would be put on the rod and the pin would not pass its centre and a broken or bent crank pin or broken rod would be the result.

SPRINGS, HANGERS OR EQUALIZER BROKEN.

The object of raising the engine up at the back end is to relieve the weight on the driving springs and the object of blocking is to keep the engine level, so that water can be carried at proper height in the boiler. It is also to relieve the weight on the good springs and prevent them from being damaged. Wood is better than iron for blocking, because it is more elastic, and beside this it is not so apt to work out of place.

SETTING UP WEDGES.

Engines should have steam up when wedges are being adjusted, because the parts of the frames that lay against the fire box become hot and expand or get longer than when the boiler is cold; for the same reason brasses should be lined or keyed, and valves should be divided while the engine is hot. Valves cannot be divided properly nor wedges or rods be correctly adjusted while an engine is cold, because of the expansion of the frames, besides this you will want steam to move the engine over the different points to see if all is right. The crank pins should be upward on the side that the wedges are being adjusted, because if the parallel rods were too long or too short and the pins were downward, or on the centres when the engine ran against the blocking under the driving wheels, the driving boxes would be held from pressing against the shoes the strain on the rod would. in some cases, prevent it. This could not occur if the pins were upward, for the bottom of the boxes would be sure to press the shoes; then by slacking all of the parallel rods each driving box will be left free for its wedge to move the box and the wedge can be adjusted as desired; in other words, if the pins were downwards and the rod prevented the wheel from moving, every driving wheel on that side would have to be slid on the track by moving the one wedge; if the pins are up when the engine is moved against the blocks you put on the track for the drivers to run against, the wedges will all be free and all the wedge has to do is to roll its own driver on the track, providing always that the rods are free. Lost motion in wedge bolts should be taken up to prevent the wedge working upward and sticking fast.

PARALLEL OR SIDE RODS.

An engine is put on its parallel centre to line and *key side or* parallel rods, because at that point the

crank pins cannot be keyed too far apart or too close together, the driving axles being held by their boxes prevent this. If these rods were keyed say with the pins upward, it would be easy to slip the wheels by keying, but when the centres of the pins and the centres of the axles are all in a line with each other and all at equal heights from the track on the side that is being lined or keyed, it is almost impossible to go wrong, if a very little judgment is used. for at that point the spaces between the pins are a perfect caliper for the length of the rod and the exact distance that the pins should be from each other, even if a pin was a half inch higher than the others the difference could not be detected with a tram or any other measurement; on any other point rods can be lined or keyed too long or too short; on parallel centres this is impossible, unless the pins or axles are bent or the pins are worn very much out of true, or that they are not at exact right angles with the pins on the other side of the engine; but if any of these defects did exist, the greatest strain on the pins would be when the engine is on its parallel centre, and the wheels would accommodate themselves to the defect by slipping on every other point except the centre. It is to remedy any of these defects that the engine should be tried on the opposite centre after lining or keying.

The reason we begin to line or key side rods at the main pin, is that you can divide the liners better, getting the same thickness of brass and liner on each side of the pin and because the main pin gives the motion to the other pins. All the other brasses both ways should be loose while the main pin brasses are being keyed. Begin at the main pin and follow up from it in rotation with the others—no matter how many rods are on that side.

Do not confound the centre of the engine with the

parallel centre. There are four centres on each side of every locomotive, two of them, the parallel centres, that is when the centres of the driving axles and centres of the crank pins are all in a line, (whether they are back or forward,) and all the same height from the track. The engine centres are the points at which the cross head is at the end of its travel at either front or back end of the guides, the exact dead engine centre being half way between the point at which the cross head stops moving and the point at which it begins to move; this centre can be found very nearly correct by the plan given on page 16, Ready Reference. These centres, however, are only needed for sitting eccentrics or giving lead to valves. An engine can be got near enough by the eye to key a main rod and it is on the engine centre, not the parallel centre, that the engine should be when the back end of main rod should be keyed, and for the reason that there is but little wear on the crank pins while the engine is passing its centre; all crank pins become oblong on this account, and if brasses are keyed snug at points where the pins are most worn, they will be too tight while passing the centres where the wear is hardly perceptible.

Cross head pins to which the front end of the main road is attached, have the heaviest strain and the most wear on them as the engine is leaving its centres, and as their brasses do not revolve on them they wear flat, so that when the engine is on its centres the brasses might be loose, while if the crank pins were up or down they might be too tight; for this reason the proper place to key the front end of a main rod is when the crank pin is down; it would answer as well to key it with the pin up, but it is generally easier to get at with the crank down. If it is keyed too tight, you will either loosen the pin or break the cross head.

TIRES BROKEN.

When tires are broken it does not matter which tire it is or how many drivers the engine has. If the tire can be taken off the engine can be run slowly to the shop by taking all the parallel rods off, only if it is the main tire the main rod must also be removed on that side.

KNOCKS AND THUMPS.

The reason the crank pin is placed upward when you wish to find a knock or thump, is because the crank pin is freer to move at that point; if the pin was downward the weight of the engine would have to be moved before you could find a thump in a driving box or frame; if the pin was on either of its centers you could get steam in only one end of the cylinder when the reverse lever is moved.

EXTENDED SMOKE BOXES.

The object of raising the apron on the diaphragm in an extended smoke box, if the fire burns too fast at the front of the fire box, is to give more draught to the top flues. The lower the apron is the harder the draught acts on the lower flues. The exhaust fills the stack as it passes out of it, leaving a void or partial vacuum in the stack and part of the smoke box. The gases from the fire box rushes at once through the flues toward the point where the greatest vacuum exists in the smoke box—this point is at the lower edge of the apron—so the height of the apron as it regulates the height of the vacuum, influences the draught in the upper or lower flues; for a trial, one fourth of an inch is enough to raise or lower the apron at a time. This amount of change has a great effect on the fire. The sparks from the fire box of an engine having an extended smoke box are thrown by the draught into the ex-

tension out of reach of the vacuum and cannot rise unless the extension is nearly full. If the netting is in good condition and properly fitted fine dust will be thrown but no large sparks.

CONVEY OR DRAUGHT PIPE.

The conditions of the convey, or what is sometimes called the petticoat pipe, are different to the apron in an extended smoke box, although both produce exactly the same effect on the draught, but while the apron has its vacuum at its lower edge only, the pipe has a vacuum above as well as below after each exhaust; so if the fire burns most at the front end of the fire box it shows that the pipe is too high and the greatest vacuum is at the bottom of the pipe; the top flues not having sufficient draught through them will fill up with ashes and coal and become choked, and a large amount of sparks will be apt to accumulate in the smoke box; so if the top flues become choked and you find many sparks in the smoke box lower the convey pipe, but if the fire burns too fast at the back of the fire box and the lower flues become choked raise the convey pipe. Engines having convey pipes and spark arresters in the stacks pulverize the sparks against the nettings or cones in the top of the stacks and after they become small enough to pass through the netting they are thrown out. If an engine does not steam well that keeps its flues and front clean with a light fire the fault is not with the convey pipe, but most likely the exhaust nozzles are too small.

CARRYING WATER.

After standing at a station or after running awhile without using steam and having the injectors at work, unless the safety valves are blowing, you cannot depend on having the full pressure of steam as shown on

the gauge. The pressure is really there, but a great deal of it is only dead steam and as soon as you open the throttle the gauge will fall back and show less pressure, because the water in the boiler was made cooler by what passed through the injector and the steam used by condensation had robbed the boiler of that much heat; the pressure is nearly all retained, but the temperature being lower steam is not generated as rapidly. The same feature of dead steam is presented after the fire is drawn; the gauge may show a good pressure an hour afterward, but if you then build a new fire you will often find that the pressure will decrease until after the fire is well started and live steam is made.

Do not place too much dependence on the water glass, especially when you first take hold of an engine, it may deceive you. Gauge cocks are the safest. Carry water in the boiler as high as you can; the more water you can carry the better for steaming, because the solid body of water retains heat much better than the part of the boiler which contains only steam, for steam has no body, it is only a mixture of water and heat. The water is only a medium for conveying the heat; it has no power in itself, all the power is in the heat which the water retains. The heat is conducted through the metal of the flues and fire box to the water. This process is called *the conduction of heat*. The water expands as soon as the heat comes in contact with it and with heat in its atoms becomes lighter than the cold water above it, and the atoms charged with heat rise to the surface, each atom giving up part of its heat to the water through which it passes; this process is called the *convection of heat*. After the water has become heated up to a temperature of 212° steam begins to form above its surface; the atoms absorb more heat and then become very small elastic balls with more spring in them than if made of india rubber, each ball

doing its best to push its neighbor away from it, and the hotter they get the more elastic they become and ultimately are so small that they are invisible, we then have high pressure steam, but it cannot be seen. No person has ever seen steam; the vapor that is seen coming from safety valves or any other place where steam is made is only the remains of the water; these atoms or *water dust* being lighter than the air when first discharged float around in the air awhile then they unite with their own element and become invisible. The steam in a boiler is hotter than the water, but does not hold its heat as long as the water; therefore, in order to retain as much heat in the boiler as possible, it is best to utilize all the room in the boiler for water that is not needed for dry steam. Another point in having plenty of water in the boiler is that you are always prepared for failure of pumps or injectors, as well as other emergencies.

A WORD TO YOUNG RUNNERS.

One of the hardest things for a young runner to learn is the art of letting pretty good alone. He usually monkeys with his wedges, rods or convey pipe or something that if let alone would answer a better purpose. He cannot be too careful about oiling. I do not mean to wash the engine down with a half gallon at the begining of a trip and then letting her run until the babbitt begins to fly, but at every station where there is time enough to put a few drops on every wearing surface and lay his hand on every such surface expecting to find it hot. Another thing he will find to be a great satisfaction to him is the thorough inspection of every part of the engine and tender before starting on a trip; it will give him more confidence while running, that he is going to get through all right, if he satisfies himself that to the best of his knowledge the engine is in

good condition before he starts and if anything should go wrong you will not have yourself to censure for want of careful examination.

STARTING A TRAIN.

The reason that a train should not be started without having the reverse lever set at full stroke, is because there is a greater pressure on the valves when steam is first admitted to the steam chests than after the engine gets under headway; while the engine is running and using steam a thin film of steam is between the valves and their seats all the time, so the valve is not in actual contact with the seat, and if the valves are allowed to move over a portion of their seats without having steam (which of itself acts as a lubricant,) or something to relieve the friction between them, the seats will in time become worn in the centres; for the same reason the lever should be placed at full stroke while the engine is drifting without steam to prevent, as much as possible, the wearing of the valve seats in the centre, and from wearing a rounding face on the valve.

The reason why an engine saves steam by running with the throttle wide open and using the reverse lever to control the admission of steam to the cylinders, is that as the engine is cut back the lead on the valve increases and admits more pressure in the cylinder just where it is needed, that is when the engine is at its weakest point right after passing its centres and nearly all of the full effective pressure of steam in the boiler remains in the cylinder nearly all of the time that the valve remains open, a little before the valve closes, the pressure entering the cylinder becomes what is known as wire drawn or weak steam, the same thing occurs if you run with your throttle partly closed, the steam becomes wire drawn before it reaches the steam chest.

If the throttle is wide open almost all of the full effective pressure of the boiler is always in the steam chest and that pressure is at the valve ready to give its full impulse up to the piston, and is more effective than if the pressure was less and longer continued by having the throttle partly closed and having the valve travel farther. If you use steam in a cylinder until the piston has traveled twelve inches, when the engine will do the work by the piston traveling but eight inches, you are wasting at least one-third of that extra steam, because you do not get the full effective pressure against the piston when it is most needed. If you strike a nail with a force of 120 pounds it is driven farther than if struck with a force of 100 pounds. So is a piston driven with more force and a greater distance with 120 pounds pressure than it is with 100 pounds pressure.

Another point is that after a piston has moved five or six inches from the end of the cylinder not near as much steam is required to move the engine for the next third of the half revolution of the wheels, because the leverage on the driving wheel increases as the crank pin leaves its centre until the pin is up or down, the leverage decreasing gradually until the pin reaches the other center, but before you reach that point you have had the full benefit of all of the expansive force of 120 to 140 pounds of pressure, and it is well known that the higher the pressure the greater the expansive force of steam and by closing the throttle the motion of the piston takes the pressure out of the steam pipes faster than the throttle allows it to flow ; immediately after passing the center you want the highest initial pressure in the cylinder that you can get there, and when the steam has done its work in that end of the cylinder you want to get rid of it as soon as possible ; and the outside lead that is gained by the valve being cut back is also gained on the exhaust cavity in the

valve, and thus you begin to release the steam sooner than if you used the throttle instead of the reverse lever. Of course there is more compression of steam between the cylinder head and piston at the end of the stroke on account of increased lead, and the exhaust is somewhat choked, because the cavity of the valve does not open so wide when the engine is cut back, but four or five inches of steam saved at each end of a cylinder more than makes up for all these losses. Your steam gauge will show that your engine will steam better with any train it can haul at maximum speed with valves cut back as far as circumstances will admit with throttle wide open, than with reverse lever two or three notches ahead, with the throttle partly closed.

HINTS TO FIREMEN.

Watch your ash pan dampers and use them when necessary. If you have more steam than you need the dampers should be closed, or if the engine will not steam with a light clear fire, close the front damper a little, because if too much air is admitted the fire will be chilled; only a certain amount of air is needed to make a fire burn as it should, and if you wish to save coal, (and saving coal means easier work for the fireman,) too much air is as bad as too little; the reason of this is that the air contains a gas called oxygen and all coal used contains a gas called hydrogen and a substance known as carbon, and all three of these bodies (like every thing else in nature,) contain heat in themselves; when oxygen, hydrogen and carbon are placed together they produce by friction what is known as caloric, which is the effect of heat, and the effect of heat on these three when united produces what is known as combustion, and this combustion of fuel is going on all the time that it is exposed to the air.

Sometimes the friction becomes so great that it produces enough of caloric to catch on fire, this is called spontaneous combustion; but as a rule no flame appears until friction is added by means of a match which being made of highly inflammable materials is made by friction to produce the desired flame which in its turn communicates its friction to the other inflammable materials to which it is applied and the friction increases constantly until the whole mass is a fire burning continually until one or the other of the ingredients is consumed; in other words, the violent chemical action attending the combustion of the ingredients of the fuel with the oxygen of the air produces fire, the hydrogen gas and atoms of carbon in the fuel uniting with the oxygen in the air produces the flame, the three elements united form what is known as carbureted hydrogen. Now, if more or less oxygen is admitted into the fire box than is needed to form a perfect mixture of these gases the combustion will be imperfect; too heavy firing or too much coal in the fire box produces the same effect and the gases without flame is drawn by the exhaust out of the stack in the form of smoke. No rule can be laid down for the exact amount of air or the exact amount of fuel required, because different qualities of coal require varying quantities of air. Keep the fire bright; you cannot make steam with a fire box and flues full of smoke.

An intelligent fireman can soon see the amount of air the kind of coal he is using needs by watching when the greatest flame appears with the least smoke coming from the stack and can carry his fire and regulate the dampers accordingly, always having a level, shallow fire and attending to it very often. Do not fire with large lumps of coal, break it to about the size of an egg, so you can keep your fire level and even in *depth.*

THE REASON WHY.

TIME AND SPEED TABLES.

					Minutes. Seconds. 10th of a Second.			
10	miles	per	hour	is	6.00	to	1	mile.
11	"	"	"	"	5.27	"	1	"
12	"	"	"	"	5.00	"	1	"
13	"	"	"	"	4.37	"	1	"
14	"	"	"	"	4.17	"	1	"
15	"	"	"	"	4.00	"	1	"
16	"	"	"	"	3.45	"	1	"
17	"	"	"	"	3.32	"	1	"
18	"	"	"	"	3.20	"	1	"
19	"	"	"	"	3.09.5	"	1	"
20	"	"	"	"	3.00	"	1	"
21	"	"	"	"	2.51.5	"	1	"
22	"	"	"	"	2.43.5	"	1	"
23	"	"	"	"	2.36.5	"	1	"
24	"	"	"	"	2.30	"	1	"
25	"	"	"	"	2.24	"	1	"
26	"	"	"	"	2.18.6	"	1	"
27	"	"	"	"	2.13.3	"	1	"
28	"	"	"	"	2.08.5	"	1	"
29	"	"	"	"	2.04	"	1	"
30	"	"	"	"	2.00	"	1	"
31	"	"	"	"	1.56	"	1	"
32	"	"	"	"	1.52.5	"	1	"
33	"	"	"	"	1.49	"	1	"
34	"	"	"	"	1.45.6	"	1	"
35	"	"	"	"	1.42.6	"	1	"
36	"	"	"	"	1.40	"	1	"
37	"	"	"	"	1.37.3	"	1	"
38	"	"	"	"	1.34.7	"	1	"
39	"	"	"	"	1.32.3	"	1	"
40	"	"	"	"	1.30	"	1	"
41	"	"	"	"	1.27.7	"	1	"

TIME AND SPEED TABLES.

					Minutes. Seconds. 10th of a Second.			
42	miles	per	hour	is	1.25.7	to	1	mile.
43	“	“	“	“	1.23.5	“	1	“
44	“	“	“	“	1.21.7	“	1	“
45	“	“	“	“	1.20.0	“	1	“
46	“	“	“	“	1.18.2	“	1	“
47	“	“	“	“	1.16.6	“	1	“
48	“	“	“	“	1.15	“	1	“
49	“	“	“	“	1.13.5	“	1	“
50	“	“	“	“	1.12	“	1	“
51	“	“	“	“	1.10.6	“	1	“
52	“	“	“	“	1.09.4	“	1	“
53	“	“	“	“	1.07.9	“	1	“
54	“	“	“	“	1.06.6	“	1	“
55	“	“	“	“	1.05.4	“	1	“
56	“	“	“	“	1.04.3	“	1	“
57	“	“	“	“	1.03.2	“	1	“
58	“	“	“	“	1.02.2	“	1	“
60	“	“	“	“	1.00	“	1	“
65	“	“	“	“	0.55.3	“	1	“
70	“	“	“	“	0.51.4	“	1	“
75	“	“	“	“	0.48	“	1	“
80	“	“	“	“	0.45	“	1	“
85	“	“	“	“	0 42.3	“	1	“
90	“	“	“	“	0.40	“	1	“
95	“	“	“	“	0.37.9	“	1	“
100	“	“	“	“	0.36	“	1	“

DESCRIPTION OF DRAWINGS ACCOMPANYING READY REFERENCE.

The best way to study the instructions given in the Ready Reference, is to have open before you the drawing of the parts on which you are seeking information. If you wish to study the working of the Westinghouse automatic or air brake, lay before you the two drawings relating to that special subject, one showing the engine and tender with brake and fixtures complete as they appear from the outside; take also the drawing that shows nothing but the brake, its pump, reservoirs and other fixtures. Then on page 35, Ready Reference, you can begin at the steam "engine and pump," and having the whole affair before you, you can trace the workings of the whole arrangement and become familiar with it from beginning to end in a short time.

In the same manner you can study setting or dividing valves: open the diagram of valve motion and on page 20, Ready Reference, you can follow up the directions there given, together with the explanation given on the diagram, and it will make valve dividing very plain to you.

If you wish to understand the arrangements on the inside of an extended smoke box, take the drawing of the consolidation or eight-wheel connected engine showing that device: you see a dotted line running at an angle from the top of the smoke box near the back part of the base of the smoke stack to the top of the exhaust pipe; this dotted line then runs straight to the front of the smoke box, then at an angle upwards to the upper corner of the extension just under the head lamp. This line represents the wire netting or spark catcher. The line that is nearest the flue sheet shows the diaphragm with its apron, the use of which is described on page 32, Ready Reference, and page 23 of this book. On this drawing you also see the arrangement

of the reverse lever, reach rod and tumbling shaft with its lever and lifting arm. These, however, are shown more fully on the diagram of valve motion. The cylinder packing, shown in this drawing, is *steam self-adjusting packing*. This engine has an injector. The fire box you will see rests on the frames of this engine, the object of placing the fire box on top of the frames is to allow greater width in the fire box, thus allowing a greater surface for the fire and a larger grate surface for draught, a lighter fire can be carried and the fuel is consumed to greater advantage than in a narrow fire-box. The arrangement of the throttle valve and steam pipes inside the boiler are also shown in this drawing, also the main and parallel rods, the driving springs with their hangers, swords and equalizers and nearly all of the valve gear.

The drawing of the consolidation engine, that has the boiler without the extended smoke box, shows the arrangement of the petticoat pipe The netting or spark catcher is known as the fish-basket spark arrester. This engine has spring packing in its cylinders. The arrangement of the throttle valve and its levers, the dry pipe and main stem pipe are shown plainly, also the arrangement of the crown sheet with its bars and other stays inside the boiler; instead of an injector a pump is shown on this engine.

Now if you are studying the instructions given about the disablement of any part of an engine, or any other thing, it is certainly a good plan to have that engine or thing to look at, for this reason it is best to refer to the drawings in every case.

MEMORANDA.

MEMORANDA